Concrete

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Children of Necessity

By Harvey Whipple
Editor of Concrete

ALEXANDER the Great died young and very ignorant. He nursed an appalling conceit and grieved that he had no more worlds to conquer—a degree of satiety that is fortunately denied to the bulk of humanity, for humanity's progressive good.

We no sooner achieve a thing and come out for a moment upon some high peak of experience than the rosy horizon retreats. What seemed to be a destination was but a wayside caravanserai where we were refreshed only to take up our packs for another stage of the journey.

When we look back at the poor and plodding Joseph Aspdin, fined by the magistrate for stealing the rock dust off the roads of England to make the first portland cement, we seem to have come a long way to the mountain-devouring machinery of the modern cement industry.

Since Smeaton needed a better cement for the Eddystone light and America needed a better cement for canals of the early eighteen hundreds, the great mother, Necessity, has brought forth her inventions year by year and her conquering progeny have gone on changing the face of the world.

All this looking backward makes a gratifying centenary celebration—a hundred years since portland cement was invented—a hundred years in which concrete became a necessity—not merely for an isolated British lighthouse or for the narrow waterways which served before the railroads could stretch their long lines across the country—but a necessity of a thousand common uses, until where permanence is sought the glib answer of every man in the street is this: "Build it of concrete."

The cement industry has grown from a paltry thing. It has grown in solidarity and in extent. Instead of a hundred different specifications and no telling what characteristics or what conformity, we have attained one standard. Smeaton, White, Aspdin, Frost, Johnson, Saylor—these were the pioneers; they pulled in whatever direction they looked. Theirs were the days of individual effort.

In was more than three quarters of a century before the cement industry learned its first lesson of solidarity, of pulling together, of unification.

Now again as the centenary is celebrated, the industry is considering what new worlds it has to conquer. The individual effort is cropping out. New cement necessities are being studied. Portland cement was and is a prodigious achievement. But the cement industry is too great to regard its present product as final. From many sources come the thought that we are at but a stage upon the journey. The new and greater uses of the cement of the future, are the unborn children of a Necessity that stands with a hand upon the shoulder of every thoughtful engineer and of every cement producer of candid mind and courageous mold.

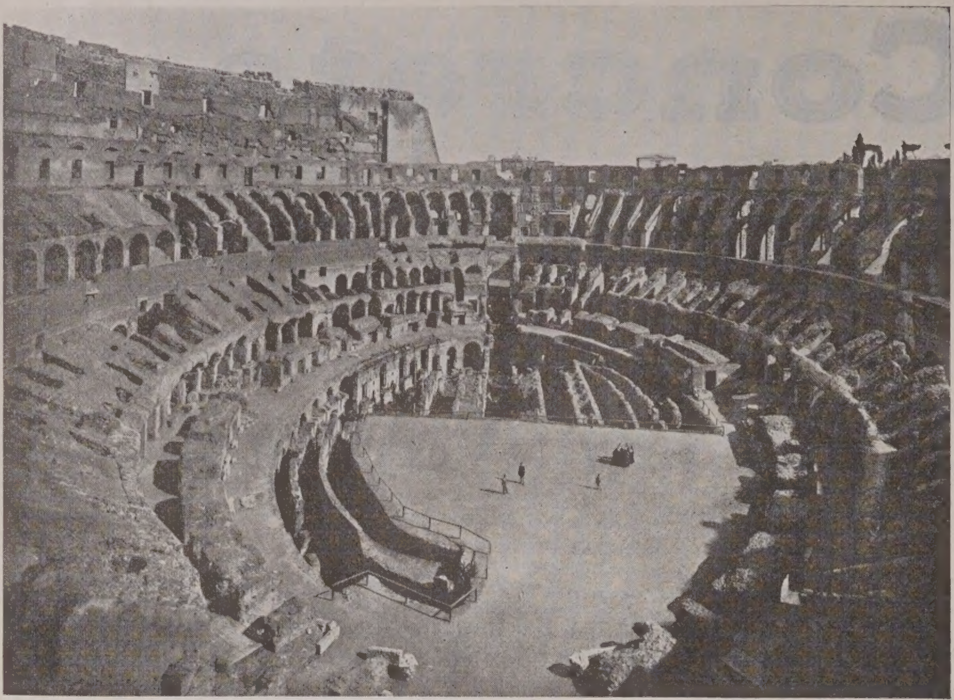


Fig. 1—Interior View of Coliseum

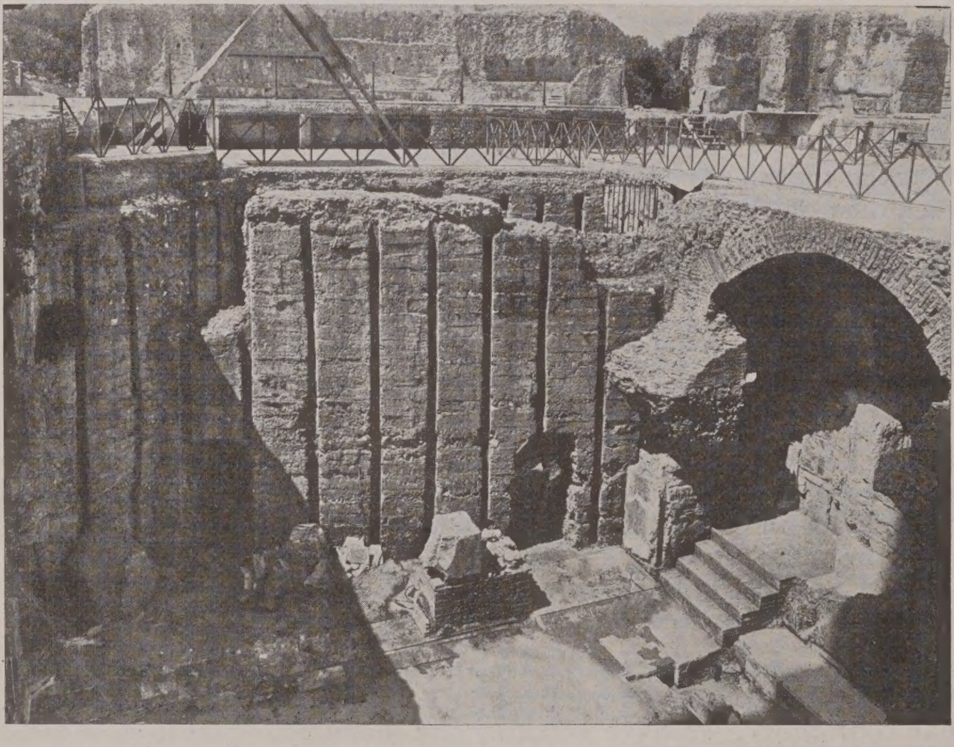


Fig. 2—Ruins of Concrete Structure Believed to Have Been Built in the Second Century

The Coliseum is One of the Few Monuments of Roman Construction That Were Built Largely of Solid Travertine Rocks, Even Without Mortar to Hold Stones in Place, and is not a Good Example of Concrete Construction. Originally the Blocks of Rock Were Held in Place by Iron Clamps, but These Clamps, During the Various Sieges of Rome, When Iron Became Scarce, Were Removed, Leaving the Holes That Are Apparent in All Views of the Outside of the Coliseum. Some of the Interior Parts of the Coliseum, as is Apparent in the Above Illustration Are Constructed of Concrete, but Outside Walls and Practically All of the Inside Supports Are Solid Travertine.

Fig. 2 Shows Unmistakably That the Method of Using Concrete in Those Days Was Practically the Same as Today. The Marks of the Forms Are Very Distinct. The Peculiar Shape of This Room is Due to the Fact That the Walls Containing the Concrete Forms Were Built, it is Believed, in the Second Century, upon the Ruins of a Former Building. The Floor at the Bottom, upon Which the Concrete Walls Stand, is the Floor of the Older Structure.

These Pictures Are Reproduced from Photographs Furnished by L. R. Burch, Vice President Atlas Portland Cement Co.

The Invention and Early Development of Portland Cement

By H. C. Badder
London, England

There was a great wave of industrialism started in the eighteenth century; those giants of constructon Rennie, Smirke, Telford, and Smeaton, with other names which loom largely in that era, were in full flower. The openng of the nineteenth century found some of them still working, while behind them more men like Joseph Aspdin, the inventor of portland cement, pressed forward with new ideas and inventions that affected the whole world. The millwrights, the forerunners of the engineers of today, were then the designers and constructors, most of whom were self taught geniuses who, by sheer constructive thinking, solved the problems that came before them.

Joseph Aspdin was born in 1779 at Leeds, a very small town in Yorkshire. Of his early days little can be gathered but it is known that he served his time to become a bricklayer and plasterer, a combined trade in those days. Oddly enough Smeaton's home was also at Leeds and he was living there while young Aspdin was an apprentice to his trade, and there can be no doubt Aspdin was aware of the work that had made Smeaton famous, as it is known that the latter employed a number of workmen about his very practical laboratory in which he experimented and tested materials for the new work he supervised, such as the rebuilding of the Eddystone lighthouse.

In those days gossip between workmen carried the news of their trade all over England, and as many of them could not read, this was their main opportunity of acquiring knowledge of new methods of construction and materials.

The germ of every invention exists in work done before its fruition, and in the case of portland cement it was John Smeaton who, experimenting during the winter of 1756, discovered, with the help of a local chemist, that a proportion of clay mixed with the lime caused the pulverized burnt materials to become hydraulic and to set slowly under water.

While this was a valuable discovery he did not carry it far enough; in the meantime he had the good fortune to find a supply of pozzolana stocked by a merchant of Plymouth who had imported it from Italy on a venture and was willing to sell it cheap.

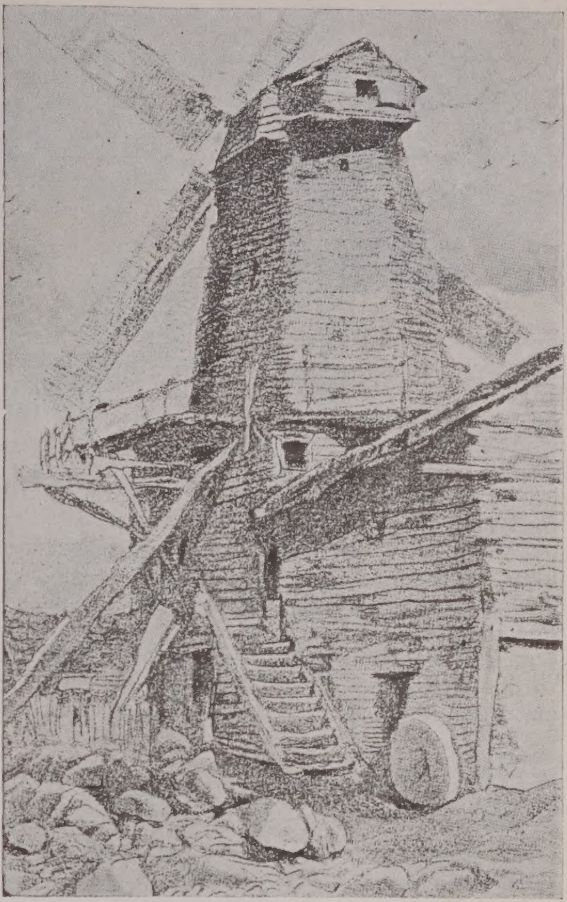


Fig. 1—Windmill Used for Grinding Cement in the Early Days

In those days and earlier, merchants ventured to import many articles and materials of which they had but little knowledge, trusting to find a use and a market for them. Smeaton's use of this chance stock of pozzolana made it so famous that its use was specified in government contracts and mortar up to 1867, over 43 years after the invention of portland cement.

Smeaton then fixed upon equal proportions of lias lime and pozzolana as the cementitious materials for his mortar used in the erection of Eddystone lighthouse, because it was comparatively quick setting and could be used between tides. These mortar joints withstood terrific storms, with few repairs, for 123 years before the lighthouse was taken down to be replaced by a larger and higher tower.

Joseph Aspdin's Early Life

There are no more details of Aspdin's early life to be found other than the important events recorded in the family Bible.

As a young man with the germs of ambition planted in his breast, he would follow the customs of his times and work at his trade wherever it was in progress. They worked from daylight to dark every day, except Sunday, for less than a dollar a day. There were few holidays, and for their leisure hours amusement was provided by the Maypole on the village green, the local fairs with their wondrous side shows, and an occasional public hanging.

By inference it may be deducted that he traveled further afield to follow his trade than most workmen, as he was 35 years of age before

Fig. 2—The Inventor's Eldest Son, William Aspdin

he married and settled down at Princess Street, New Road End, Leeds. This event took place in 1812, and in 1813 he was the father of a son whom he named William and of a second son in 1814 who was called James. Both of them, as boys, would have some knowledge of their father's inventive efforts, and the removal of the family to Wakefield when William was about 12 years old would be a tremendous event in their young lives.

How long Aspdin had been experimenting to find the proper mixtures of materials to make his cement is not known, but a story was told by old workmen 50 years ago that Aspdin was fined by an irate Justice of the Peace for taking limestone off the roads, and this may be why, with grim humor, he mentions "road sweepings" in his *Patent Specification of 1824*, here reproduced in facsimile.

Fig. 3—James Aspdin, Second Son of Joseph Aspdin

A news paragraph in the *Leeds Mercury* of November 6, 1824, states: "We hear that Joseph Aspdin, bricklayer of this town, has obtained a patent for a superior cement representing Portland Stone."

Aspdin's First Portland Cement Plant

At Wakefield, Aspdin set up the first portland cement works upon a commercial scale in Ings Road, and his first difficulty was the grinding of his raw materials. The opinion still prevailed that a hard limestone must make a strong lime or cement, naturally he would try it, but there was only water power or windmills to drive his millstones so the grinding would be a long and costly task, however, he worked his way out of this difficulty by first burning the limestone to lime in an ordinary rough limekiln and the grinding difficulty was solved.

He had failures, too, in burning his mixture of equal weights of lime and clay, which he mixed in a slip pan and then dried and broke into pieces, which were placed alternately with fuel in a kiln and burned. The temperatures of his first kilns were not high enough for his purpose and he developed a type of bottle kiln which gave him a stronger draught, and by this means the heat produced his portland cement which, when picked over and ground between grit millstones to a powder, was ready for sale and use.

The dificulty in introducing his cement to the building trade was productive of more trouble, and the general use of portland cement was very slow, for the increasing use of Roman cement invented by James Parker in 1791 was hard to overcome. It was by the way of portland cement mortar and stucco renderings to walls it gradually progressed into use for mass concrete foundations.

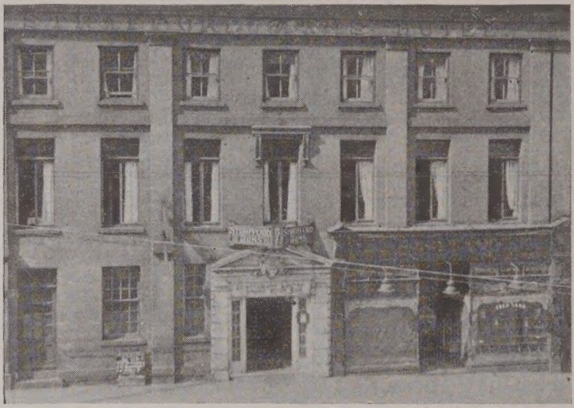


Fig. 4—A Portland Cement Stucco Job Done by Joseph Aspdin 100 Years Ago

In a book published in London in 1829 entitled *The Bricklayer's and Plasterer's Guide*, portland cement is not even mentioned.

It has been repeatedly published that portland cement was used by Sir J. Brunel in the construction of the Thames Tunnel, but this is an error, as the semi-official history states that Roman cement was used, though the work was not completed until 1840.

No doubt efforts were made to introduce portland cement before the structure was completed, as Mr. Francis, of the firm of Francis & White, portland cement manufacturers, supplied Brunnel, with free samples in 1832 and that genius used it to carry out tests for bridge arches he had under design, in which he used flat iron bars to reinforce the work that was quite successfully carried out for his test.

Aspdin struggled on while his sons, now growing up and becoming useful, were learning all that was known about the cement. The value of his invention was discovered and he had offers of assistance to establish works elsewhere. A proposal to erect works near London was made and the firm of Maude, Jones & Aspdin was formed to manufacture portland cement at Northfleet, on the banks of the Thames near Gravesend, in 1828. In 1834, while Aspdin continued his operations, his son William, restless and eager for a change, traveled south to take over the technical charge of manufacture; he had worked out the details of improved methods of making cement and wanted them tried out.

William was a very clever young man, constantly improving processes to perfect the cement invented by his father, but partners then, as now, were not so ready as he to scrap machinery in use, or try out improving processes they did not

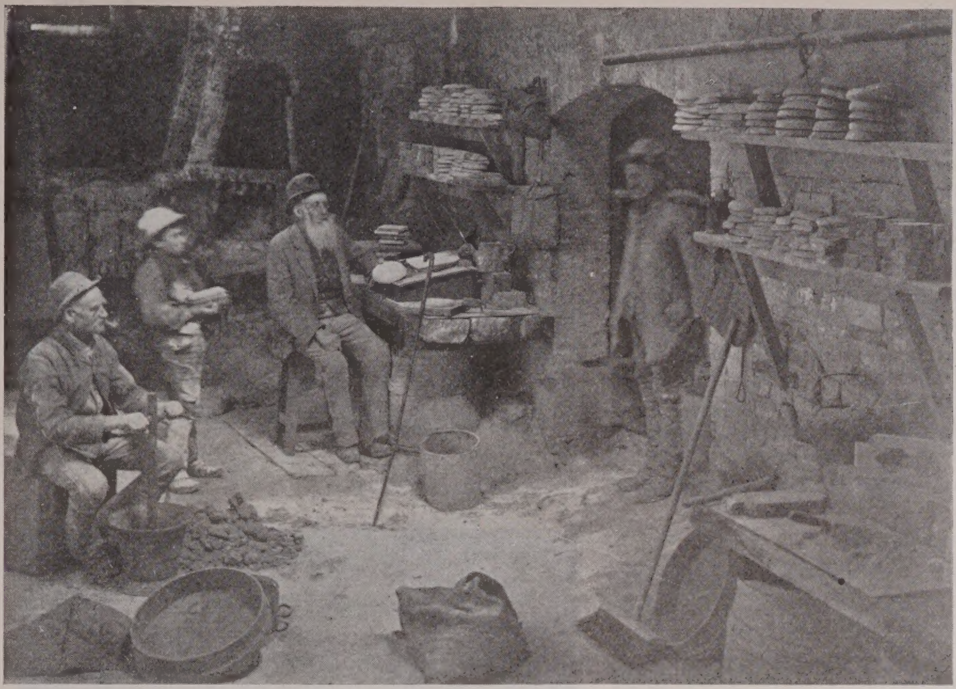


Fig. 5—Old Portland Cement Testing Laboratory

understand. High spirited and impatient of delay, he had numerous quarrels with his associates. After the Great Exhibition in Hyde Park, London, at which experiments and tests of portland cement were made before Sir Charles Pasley, he left London in disgust and started new cement works at Newcastle-on-Tyne. He did not settle down there although he got married. Again, he did not get on well with his partners and in 1854 he was induced by a Mr. Forester to go to Germany to erect and control a cement works near Berlin, taking his family with him. Leaving these works in a good running order he started up a second works at Hamburg and a third at Lagerdorf.

Fig. 6—Northfleet, 1718, Site of Portland Cement Works Started by William Aspdin

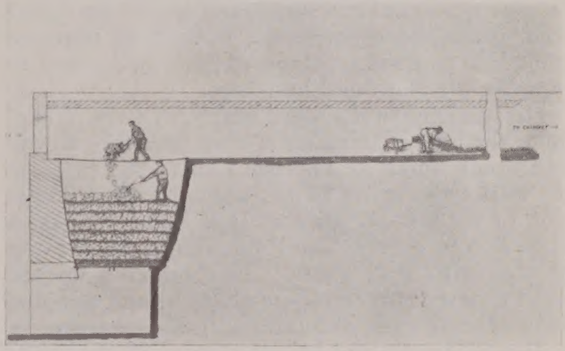


Fig. 7—Chamber Kiln, 1872

His difficulties gave him a strenuous nine years under which his health broke down, and his death occurred at Lagerdorf in 1863 at the early age of 49. He had been so unbusiness-like that he died poor and had left nothing for the support of his wife and family, who had to return to England poorer than they left it.

There is no doubt this son of Joseph Aspdin was far in advance of any living contemporary in the manufacture of portland cement. His eager mind reached out for more exact methods and improved kilns and machinery. The limitations of his various associates enraged him, and, as his family said of him, "He supplied the brains and the others got the financial benefits." The quality of the cement made in German works during 1855-65 proves their contention.

Few details are available regarding William Aspdin's stay and work in Germany but during his management of the cement works on the Tyne he issued a pamphlet that attracted great attention at the time. It is in the main an additional proof of his knowledge of portland cement work.

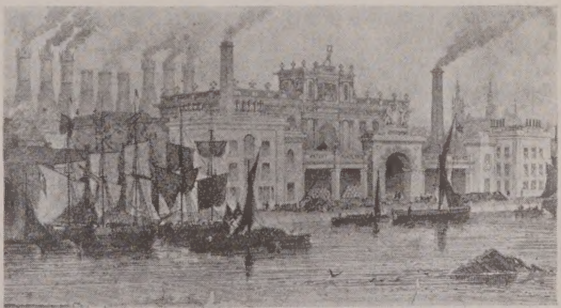


Fig. 8—William Aspdin's Cement Works, Newcastle-on-Tyne

The heading of Aspdin's pamphlet is reproduced here:

Plain directions for the use of patent portland cement in the pamphlet stated that the cement should be mixed to the consistency of mortar and applied immediately. The work on which it was to be used was to be previously wet—and when once the cement had set, it was not to be mixed a second time because the setting process, once disturbed, could not be restored. The directions given were for doing such work as moldings, flooring and paving, castings and water works.

A statement of the results of experiments testing the strength of patent portland cement manufactured by Messrs. Aspdin, Ord & Co. and tried at their wharf, Abingdon St., Westminister, Feb. 10, 1853 treated: compression with a hydraulic press, cohesion, cross strain and adhesive power.

James Aspdin

James Aspdin did not follow his brother into the cement works, but entered the drapery business, in which he was engaged for some years; he married in 1834 but had no family. He gave up his employment when his brother William left Wakefield to go to London and the cement works at Gravesend, and joined his father who, grim and determined, worked to improve the quality of the portland cement made, and to improve his plant and buildings.

His various works were scattered over Wakefield; the lime burning kilns were near the railway and other works in Thornes Lane. His pride in his works was made visible when, on the completion of his last building at Ings Road, he cast a huge lion in concrete and mounted it on the top of the front wall gable. This building existed until recent years, but was changed and adapted for a skating rink, and later still, for a garage.

Joseph Aspdin and his son carried on the works together until the end of the year following William Aspdin's departure to Germany, then the inventor's health failed, and he died at the ripe age of 76 years. He was buried in Saint John's Churchyard, Wakefield, and upon his tombstone is inscribed the following epitaph:

Sacred
To the Memory of the Late
Joseph Aspdin of this Town
(Inventor of the Patent Portland Cement)
Who Departed this Life on the
20th Day of March, 1855
Aged 76 Years
Also of Mary, Wife of the Above Named
Joseph Aspdin, Who Departed this Life
on the 1st Day of February, 1865
Aged 84 Years

After his father's death James Aspdin took full charge of the works for his mother and himself until her death recorded above in 1865. He carried on for a few more years, and died on the 21st of December, 1873, at the age of 60 years.

The works were then sold to a company who continued the manufacture of portland cement, but for lack of practical knowledge they failed to make profits on their capital and finally closed down and sold the property.

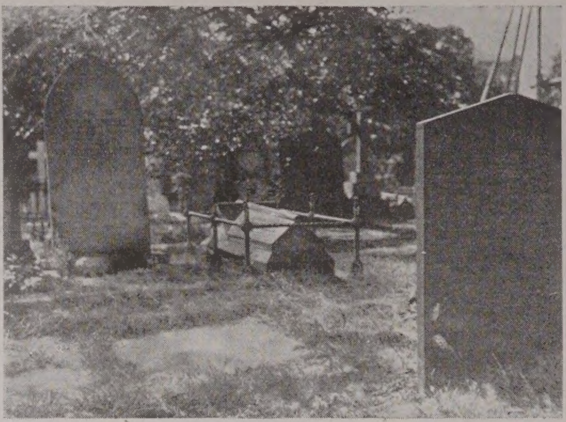


Fig. 9—Joseph Aspdin's Grave Stone, St. John's Churchyard, Wakefield, Yorks

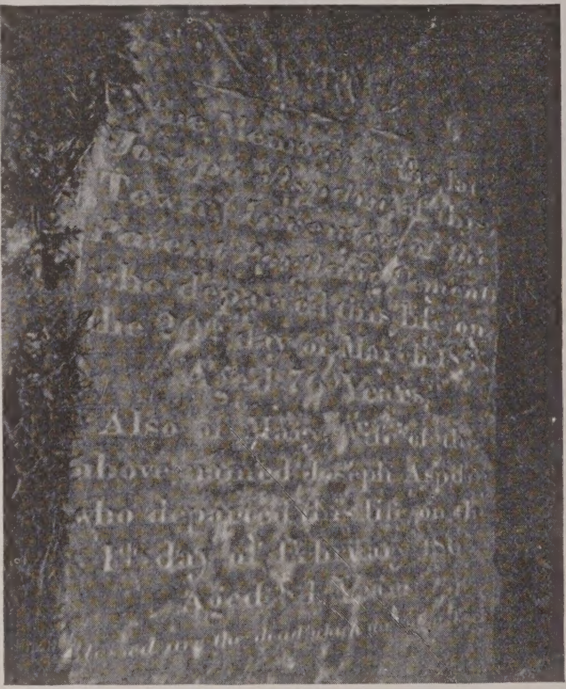


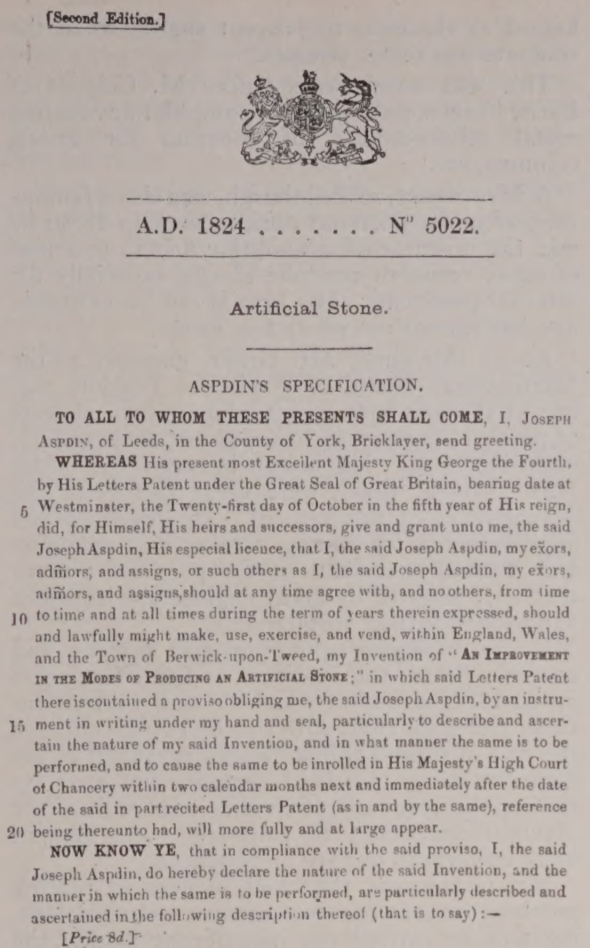
Fig. 10—Wording on Joseph Aspdin's Grave Stone

A number of buildings that were partly constructed of portland cement concrete or finished with a cement rendering from 1853 are still standing in good condition at Wakefield—the old Saw Inn, The Wakefield Arms, Strafford Arms, a chapel in Market St., and Brotherton's Chemical Works.

Strangely enough James Aspdin was the last of his name to be directly engaged in portland cement manufacture. His brother's widow brought two sons and four daughters home to Dewsbury, Yorkshire, of whom only the youngest daughter, Miss Aspdin, now an elderly lady, still survives.

At this date there lives a youth of 18 years, the great grandson in direct descent of the inventor of portland cement, who bears the name of Joseph William Aspdin, who is the only male representative of the family now living.

At the Great Exhibition in 1851, portland cement did not do itself justice, and if the firms then making cement had spent more money and had made a striking exhibit, the advance in the general use of portland cement would have been more rapid. Two firms did try to call attention to the value of portland cement; Robins, Aspdin



[Second Edition.]

A.D. 1824 . . . . N° 5022.

Artificial Stone.

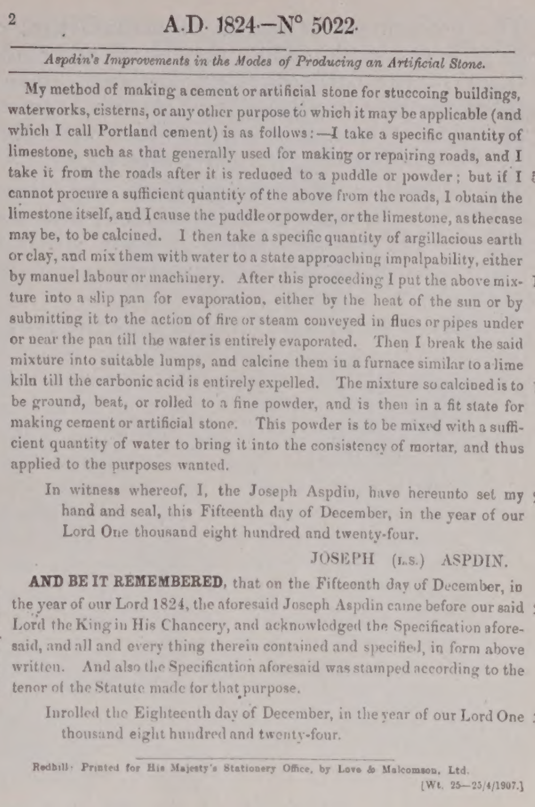
ASPDIN'S SPECIFICATION.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, Joseph Aspdin, of Leeds, in the County of York, Bricklayer, send greeting.

WHEREAS His present most Excellent Majesty King George the Fourth, by His Letters Patent under the Great Seal of Great Britain, bearing date at Westminster, the Twenty-first day of October in the fifth year of His reign, did, for Himself, His heirs and successors, give and grant unto me, the said Joseph Aspdin, His especial licence, that I, the said Joseph Aspdin, my ex̃ors, adm̃ors, and assigns, or such others as I, the said Joseph Aspdin, my ex̃ors, adm̃ors, and assigns, should at any time agree with, and no others, from time to time and at all times during the term of years therein expressed, should and lawfully might make, use, exercise, and vend, within England, Wales, and the Town of Berwick-upon-Tweed, my Invention of "**An Improvement in the Modes of Producing an Artificial Stone**;" in which said Letters Patent there is contained a proviso obliging me, the said Joseph Aspdin, by an instrument in writing under my hand and seal, particularly to describe and ascertain the nature of my said Invention, and in what manner the same is to be performed, and to cause the same to be inrolled in His Majesty's High Court of Chancery within two calendar months next and immediately after the date of the said in part recited Letters Patent (as in and by the same), reference being thereunto had, will more fully and at large appear.

NOW KNOW YE, that in compliance with the said proviso, I, the said Joseph Aspdin, do hereby declare the nature of the said Invention, and the manner in which the same is to be performed, are particularly described and ascertained in the following description thereof (that is to say):—

[*Price 8d.*]



2 A.D. 1824—N° 5022.

Aspdin's Improvements in the Modes of Producing an Artificial Stone.

My method of making a cement or artificial stone for stuccoing buildings, waterworks, cisterns, or any other purpose to which it may be applicable (and which I call Portland cement) is as follows:—I take a specific quantity of limestone, such as that generally used for making or repairing roads, and I take it from the roads after it is reduced to a puddle or powder; but if I cannot procure a sufficient quantity of the above from the roads, I obtain the limestone itself, and I cause the puddle or powder, or the limestone, as the case may be, to be calcined. I then take a specific quantity of argillacious earth or clay, and mix them with water to a state approaching impalpability, either by manuel labour or machinery. After this proceeding I put the above mixture into a slip pan for evaporation, either by the heat of the sun or by submitting it to the action of fire or steam conveyed in flues or pipes under or near the pan till the water is entirely evaporated. Then I break the said mixture into suitable lumps, and calcine them in a furnace similar to a lime kiln till the carbonic acid is entirely expelled. The mixture so calcined is to be ground, beat, or rolled to a fine powder, and is then in a fit state for making cement or artificial stone. This powder is to be mixed with a sufficient quantity of water to bring it into the consistency of mortar, and thus applied to the purposes wanted.

In witness whereof, I, the Joseph Aspdin, have hereunto set my hand and seal, this Fifteenth day of December, in the year of our Lord One thousand eight hundred and twenty-four.

JOSEPH (L.S.) ASPDIN.

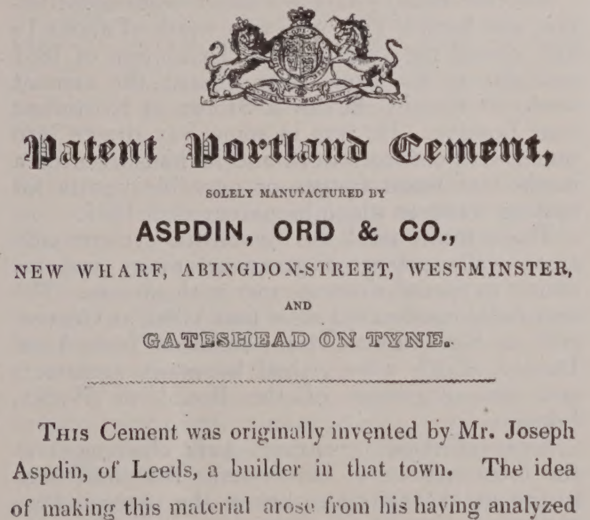
AND BE IT REMEMBERED, that on the Fifteenth day of December, in the year of our Lord 1824, the aforesaid Joseph Aspdin came before our said Lord the King in His Chancery, and acknowledged the Specification aforesaid, and all and every thing therein contained and specified, in form above written. And also the Specification aforesaid was stamped according to the tenor of the Statute made for that purpose.

Dunning, Extra.

Inrolled the Eighteenth day of December, in the year of our Lord One thousand eight hundred and twenty-four.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.
[Wt. 25—25/4/1907.]

Fig. 11—Copy from Patent Office, Joseph Aspdin's Specification of His Patent, 1824



Patent Portland Cement,

SOLELY MANUFACTURED BY

ASPDIN, ORD & CO.,

NEW WHARF, ABINGDON-STREET, WESTMINSTER,

AND

GATESHEAD ON TYNE.

This Cement was originally invented by Mr. Joseph Aspdin, of Leeds, a builder in that town. The idea of making this material arose from his having analyzed

Fig. 12—Copy of Heading of William Aspdin's Pamphlet

& Co., and John B. White & Sons, and they had exhibits and made tests before Sir Charles Pasley who had missed the renown of being the inventor of portland cement by four years. In his treatise upon *Limes and Cements* of 1847, he tells his story that though living and working within a few miles of Robins & Aspdin's works, he never heard what they were doing and making. Nor did he know portland cement was made at Wakefield until he met Aspdin at the Hyde Park Exhibition.

In the same treatise he states: "At present there are three factories of artificial cement in England, first, that of John B. White & Sons at Swanscombe, Kent, who are making a good cement which they are calling 'Portland Cement'; second, Evans & Nicholson of Manchester, who call their's 'Patent Lithic Cement' though made of the same materials; and third, Mr. Richard Greaves of Stratford-on-Avon, who calls his 'Blue Lias Cement.'"

When Aspdin's patent expired, a Mr. Frost, who had started works at Swanscombe, Kent, in 1825 to make Roman cement, took up the manufacture of portland cement in which enterprise he failed, and J. B. White & Sons purchased the works in 1845.

These firms mentioned by Sir Charles Pasley are still manufacturing portland cement in 1924.

Sir Charles Pasley was a Major General in the Army and when instructed by the government to investigate limes and cements, (which he did for about 10 years), he would have soldier workmen at command who did not mix with civilian workmen, and the gossip of the countryside would not reach them. This would partially account for Sir Charles Pasley's lack of local knowledge of what works near Chatham were manufacturing cements.

At the International Exhibition of 1861, the firm of Knight, Bevan & Sturge exhibited a 5-ton block of portland cement. The catalog of the exhibition contained a six-line description of this exhibit which included the firm's name and address. The advertising of this period mostly appeared in directories and contractors were announcing their readiness to do work in portland cement. In 1862 portland cement was used in the mass concrete foundations of the Crystal Palace when it was removed from Hyde Park to Sydenham, now a suburb of London.

The preliminary processes of manufacture of cement were conducted in a very rough and ready manner in the early days of portland cement, and the mistakes, resulting in a "blowing" cement from excess of lime, were made, which were difficult, if not impossible, to rectify afterwards.

The control of the mixing of the ingredients was left to a foreman or old workman, who was credited with the possession of some specially acquired knowledge not to be imparted even to his own employer.

Samples of slurry were brought from the works, were placed upon a drying floor and the water in it evaporated; it was then transferred to a little kiln and was calcined with coke into a hard clinker. This was ground into a powder by means of a pestle and mortar, and the powder gauged into pats with water and put up on a shelf to set for a certain period in air, then they were placed in cold water, where they were allowed to remain for 24 hours. An assistant then took the pats from the water and handed them to the foreman, who decided whether the cement made 2 or 3 days previously was of the correct quality or not. Upon examination of the pats he probably decided that a further quantity of chalk or clay should be added; then a quantity of material containing an excess of clay or chalk was added to the faulty slurry, but no proper mechanism was provided for amalgamating the two in correct mixtures.

Early Concrete Work

It is difficult to get reports of early concrete work authenticated; the word cement was often used without any qualifying prefix; Roman cement was greatly used up to 1865, then portland cement gradually superseded it. In the case of the Crystal Palace, mentioned above, the evidence is official. All the brickwork was laid in Roman cement mortar, and where the brick was stuccoed or rendered the work was done with portland cement and it is standing today finely molded with the mitres perfect.

To review the general use of portland cement by the building trade from the time it was invented is a difficult task. One of the earliest references is *Taylors Builders Price Book* for 1851 which contains some advertisements, one of these inserted by Messrs. J. B. White & Sons, states:

> Their portland cement possesses all the properties of the best Roman cement, but has the advantages of that material of wholly resisting frost when used as stucco, it does not vegate or turn green in damp situations, and requires no coloring. Address their office at Milbank Street, Westminster, or East Street, Blackfriars, London, and at 30 Seel Street, Liverpool.

The reader will note that this advertisement is written in the third person, not direct as in these days.

An early advertisement was one issued by W. B. Wilkinson in the directory of Newcastle-on-Tyne for 1841 as a master plasterer and dealer in plasters and cements; Roman cements may be meant, but he became famous as a contractor for portland cement work. He was probably the first to construct stairs of portland cement concrete and he took out a patent in 1854 for the use of wire rope or other form of iron embedded in concrete for floors, and his drawings show how iron rods, ropes or bars should be twisted or looped at the ends to prevent sliding when the concrete was under stresses.

This was seven years before M. Coignet of Paris, France, published his pamphlet advocating metal reinforcement of concrete for floors, columns, etc.

A Mr. Stuart, of Edinburgh, was also a famous contractor for portland cement work in 1850; he was the inventor of granolithic floors, and also of many forms of concrete blocks, especially for internal partitions. His firm is still in existence and has carried out many fine works.

About this time, Mr. Grant, engineer to the Metropolitan Board of Works for London, was one of the first men to introduce technical tests of portland cement and carried out thousands of experiments for his board between the years 1858 to 1871, which were great factors in the development of this cement. He devised many improvements for testing cement and concrete, and drafted specifications for portland cement that were adopted by many engineers, with slight variations for their requirements.

He read papers upon portland cement and concrete before the Institute of Civil Engineers up to 1871, in one of which he said that it was to be regretted that, with one or two exceptions, the rule of thumb still so largely prevailed in the manufacture of portland cement, and that by raising the standard of quality still higher, the manufacture would be improved, and cement more uniform in quality be produced.

Mr. Grant was the chief pioneer in placing portland cement concrete upon a technical footing and he carried out magnificent works; the Thames Embankment, and the Metropolitan Main Drainage are sound to this day.

Another noted character in concrete construction was Joseph Tall, who as a youth of about 16 had visited the International Exhibition of 1861 and during the same year visited the cement works of Knight, Bevan & Sturge at Northfleet near London. He was in some way drawn into touch with concrete work and he had invented a method of wood frames or movable panels for casting concrete which he patented in 1865.

These forms used for monolithic cement concrete walls attracted great attention and his efforts to spread their use met with success. The first buildings erected were four villas at Gravesend in Kent upon land purchased from Lord Darnly, which were visited by many architects and also engineers of the Board of Works, London.

Some of these inventions were challenged as the introductions of old systems that had been in use at various times before the patents were secured. Cresy's Cyclopedia of Engineering shows wood cuts, and gives information of such appliances to be used for the same purpose.

Mr. Tall was young both in age and practical experience so his circulars and descriptions contained loose statements. He stated that the strength of concrete was ten times that of brick walls, and his costs were all wrong.

However he sold his building forms in great number, and his work attracted the Emperor's attention at the French Exhibition of 1867, for whom he constructed several buildings very successfully, and he was rapidly making a fortune. A company was formed to carry on his business upon a large scale, and trouble arose owing to the sale of apparatus to anyone without any knowledge of building who made mistakes and caused accidents and brought the system into discredit.

He had been living in stylish circumstances at Dulwich, but his business knowledge was not equal to that of his associates and when the crash came it was he that was ruined. His fall was great and he has not yet recovered his position. Mr. Tall is now living at Coggeshall, a small village in Essex, and at the age of 77 is still cheerfully nursing hopes of making a recovery of his fortune by means of new inventions. He undoubtedly did much to bring the subject of concrete to the notice of the general public and thereby played a very big part in the present day history of this material.

A Mr. Drake, one of his foremen, took up the manufacture of concrete block machines, but concrete work received a thorough set back through the failure of Tall's company and it was years before new methods were again put into practice for monolithic concrete wall construction.

Between 1860 and 1870 many patents were secured for concrete block and brick machines, but few, if any, survived the test of practical use.

Henry Reid, who was the first consulting concrete engineer, published a volume in 1869 entitled *A Practical Treatise on Natural and Artificial Concrete, Its Varieties and Constructive Adaptions*, in which he said:

> The ultimate practical outcome of these investigations (Smeaton's) was the invention of portland cement by Aspdin, who, without chemical knowledge, and guided by his own experience as a working bricklayer, arrived at the effective result by a simple combination of raw materials which secured an artificial hydraulic cement of surpassing value.
>
> Notwithstanding the advantages which this discovery, or rather its practical application, secured, much reluctance has been displayed, and even now (fifty years since its introduction), in accepting portland cement with that confidence which such a material possessing so many constructive merits deserves.

The greatest discovery in methods of manufacturing portland cement was the invention of the rotary kiln, first patented in 1869 by Mr. Ransome to supercede brick built kilns. After arousing great expectations, it proved to be a failure in England but, perfected in the United States, it was brought back to England as an American invention and successfully used in cement works since 1903.

Until this date portland cement was made in intermittent bottle kilns or in continuous chamber kilns, the first of which was invented and patented in 1872 by I. C. Johnson.

Millstones were also used until the invention of the ball and tube mills in the beginning of the twentieth century.

The action of the present grinding machinery is quite different from that of the old millstones which ground the cement in a confined space between two close running surfaces without any free passage of air.

Of other concrete work constructed in addition to those already mentioned was some cast concrete, ornamented and enriched, formed in situ by a Mr. Millar in 1870 at some fine residences on the Redcliffe Estate, West Brompton, London.

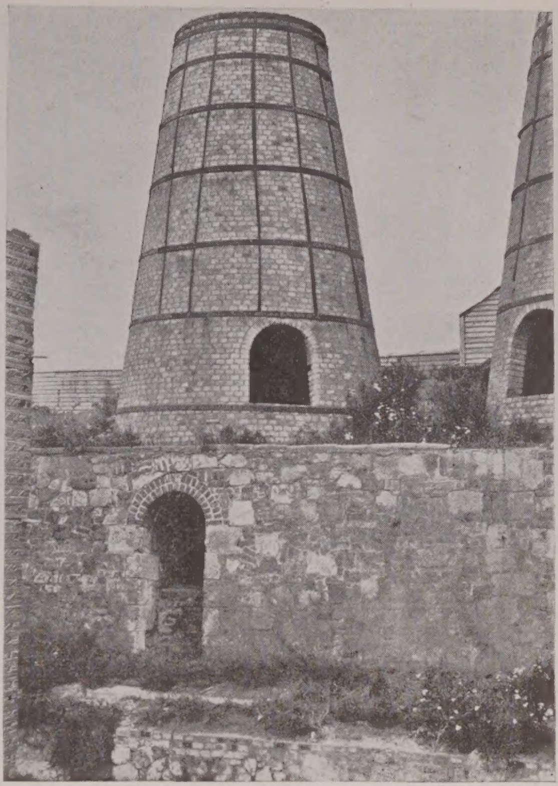


Fig. 13—Old Bottle Kilns, 1825

Waterlow & Sons, printers of Hill street, Finsbury, London, after experiencing loss by fire had the floors of their new building constructed of concrete in 1872.

A residence in Friends Road at Croydon near London, and also some cottages near by, were constructed of concrete slabs by Henry Lascelles, in 1878, who was a well known pioneer in concrete work.

Out of London some concrete houses were constructed in 1870; they were designed and built by John Pope & Son, architects and builders of Folkestone, Kent. Iron forms were used which were raised as the work of filling progressed, the outer walls were 14 in. thick and the partition walls inside 6 in. thick; the concrete was used in the proportions 1 part portland cement 1 part sharp sand and 9 parts shingle, and in the main walls, where possible, suitable lumps of coarse rock were placed in the concrete as plums to lower the cost. The total height was about 60 ft., and the exterior was rendered with portland cement and sand in the usual way.

The Marine Crescent, as it is named, consists of 14 houses, and faces the sea on the Lower Promenade. The houses are arranged in the form of an arc of a circle. They are still standing and have been occupied ever since erection, having proved warmer and drier than most brick houses do in such an exposed situation.

During 1881 and onwards the Folkestone Cement Works supplied great quantities of portland cement for the new harbor at that place. The raw materials, grey chalk and gault clay, were obtained close by the works and the total output was about 120 tons per week from shaft kilns. Many types of kilns were introduced at this date. Those used at the works of Mr. Campbell at Wouldham Valley, Kent, were designed to con-

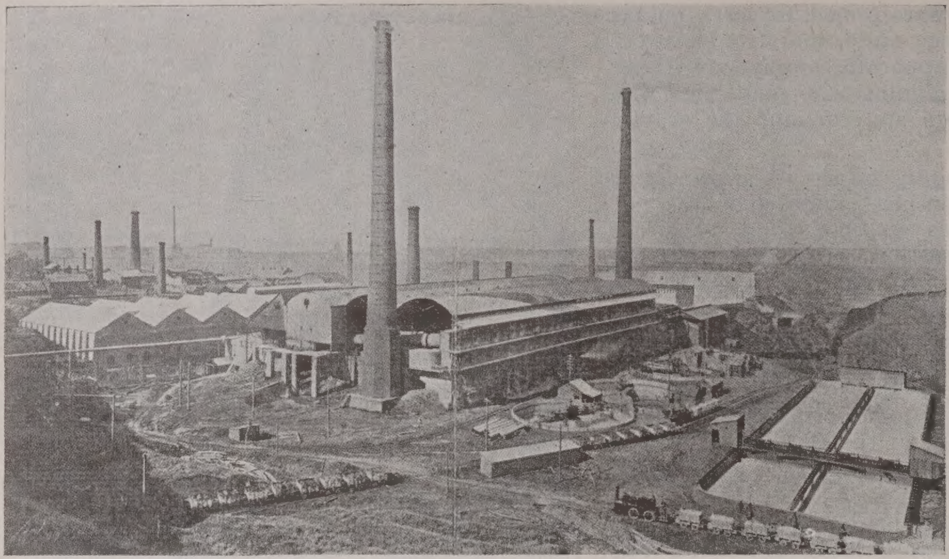


Fig. 14—The Associated Portland Cement Manufacturers' Works, Swanscombe, Northfleet, Kent

sume the noxious gases caused in burning the portland cement.

Bartholomew's *Specifications for Practical Architects*, published in 1886 as a text book, had only half a page devoted to concrete out of a total of 400 pages. All that is said about concrete is as follows: "A concrete floor is to be formed for the beer and wine cellar, six inches thick, well beaten down and smoothed at top."

During 1880 to 1890, the portland cement trade became stagnant largely owing to the financial success which attended this stage of its history. The methods of manufacture practised were known to but a few who, with well established brands of a new and eminently useful material, had practically a monopoly of the English trade and, for a considerable period, the trade of the world. For many years the principal works were content to use primitive methods and old fashioned machinery by means of which, under conditions of plentiful trade and absence of competition, the manufacturers were able to amass considerable fortunes without any particular attention to reduction of the cost of manufacture or improvement in the quality of the product.

It was not until toward the end of the nineteenth century that developments on scientific and economic lines were undertaken by the stress of competition. This was the period when engineers imposed specifications of varied character until the adoption of the British Standard Specification for Portland Cement in 1904, just after the perfected rotary kiln arrived from the United States in the same year.

At the Admiralty Harbor Works at Dover (Mr. Druce resident engineer), of the original pier in 1865, 1000 tons of portland cement were used at one time each working week; Mr. Druce standardized the cement by aeration, which proved satisfactory. The contractors, Pearson & Sons, considered that this aeration was done at no great cost to them as they bought the cement by weight and used it on the works by measure, so that the expansion of the cement without loss of strength was a gain to them when measured for the work.

This question of aeration of portland cement was discussed for years by engineers and it was not until 1911, some years after the introduction of the first British Standard Specification for portland cement, that H. Kelway Gwyer Bamber read a paper at the Institute of Civil Engineers upon this subject, which was discussed by Sir William Mathews, Dr. Dyckerhoff, R. Feret, Dr. Michaelis, Mr. Clifford Richardson and others, when it was practically decided that aeration was not now required by properly treated cement from the works.

It was stated by some of the speakers that on important work the bulk cement emptied out of the sacks had been turned as many as seven times during seven weeks to thoroughly aerate it, and the most popular test was to boil a pat of set cement for six hours for proof of quality.

About this time Dr. Bindon B. Storey, E. C., was constructing the North Wall at the Port of Dublin, Ireland, where he made concrete block 23 ft. at the base by 26 ft. deep and 10 ft. on the face, which weighed 330 tons each. These block were made on the shore, left to harden for a long time and then floated out to the required position at the rate of one block at each tide. The concrete for the block was composed of one part of portland cement to ten parts of aggregates.

Mr. Bernays, a civil engineer in charge of the Chatham dockyard extensions in 1866, found that one part of hydraulic lime to six parts of ballast (aggregate) was inferior in strength to one part of portland cement to twelve parts of ballast, the cost being identical. He had been using Greystone and Blue Lias lime for ordinary mortar and for concrete work Blue Lias lime mixed with pozzolana, and for mortar joints below high water mark Roman cement. By 1870 he was using portland cement on the work and between that year and 1880 over 50,000 tons of this cement were employed of a fineness that gave a residue of 25% on 2500 meshes to the square inch and weighed 99 lbs. per bushel.

About 1865 Mr. Greaves, who is mentioned in Sir Charles Pasley's list of portland cement manufacturers, was not satisfied with the process used in his works and therefore visited Boulogne, France, and secured a Mr. Thoroud, a French chemist employed at the cement works in that city.

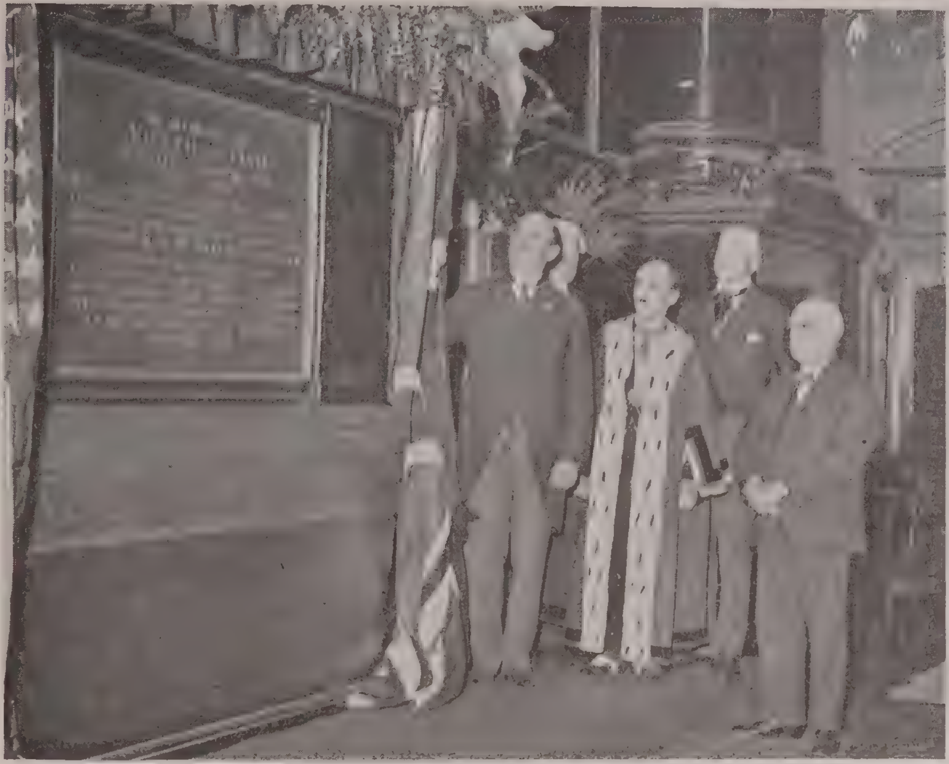


Fig. 15 — Unveiling the Bronze Memorial Presented by the American Portland Cement Association to the British Cement Makers' Federation, in Memory of Joseph Aspdin

Chemists were at that time employed at three cement works the others being on the Thames and the Medway and a great advance was made, as for the first time the raw materials were mixed and ground together into a thin slurry which was then pumped on to iron plates heated by waste steam, the dried slurry being burned in bottle kilns and ground between mill stones.

This process of burning remained in use for years, and it was not until 1870 that Mr. Greaves had chamber kilns installed together with improved machinery for grinding both the raw materials and the clinker, when the importance of fine grinding began to be realized.

The next period of improvement was about 1900 when continuous kilns with ball and tube mills were introduced and the millstones became obsolete.

In the year 1913 a complete rotary kiln plant was installed and by 1920 the old steam raising plant was discarded and the works driven electrically, the power being obtained from an electric power company in the neighborhood of the cement works.

Other cement works, especially those on the Thames and Medway, also improved their plants first with steam power which, with new grinding machinery, abolished all the old methods so quickly that it is almost forgotten by the present generation of portland cement makers.

On September 8, 1924, many members of the American Portland Cement Association assembled at Leeds to pay tribute to Joseph Aspdin. Earlier in the year they had sent over a bronze tablet commemorating the centennary of the date on which Aspdin patented his discovery. The tablet which had been set in the Town Hall, was unveiled by F. W. Kelley, president of the American Portland Cement Association. Simple in its design, the memorial is 5 ft. wide, 3 ft. 6 in. high and bears the following inscription:

> In Memory of
> JOSEPH ASPDIN,
> of Leeds, Stonemason, 1779-1855,
> Whose Invention of Portland Cement, Patented 21st October, 1824, Followed by a Century of Improvement in its Manufacture and Use, Has Made the Whole World His Debtor. This Tablet Was Presented by the American Portland Cement Association on the Occasion of the United Celebration with the British Cement Makers' Federation of the Centennial of the Invention, October, 1924.

In criticism of the printed reports of the unveiling of the tablet, it should be pointed out that Apsdin was a brick layer—not a stone mason—and his invention was not the result of an accident but that of a poor inventor's patient efforts.

A synthetic limestone brick which, it is claimed, will revolutionize building, has been manufactured successfully and used in the construction of two test houses in London, according to a report by Lowell C. Pinkerton, of the American consulate general, to the Commerce Department. Not only can the brick be made twice as quickly as ordinary brick but it is also asserted that the cost of manufacture is 30% less. The bricks are made of cement, sand, and a chemical, instead of water.

The composition has been named "cesalith." It is reported that nearly 2,000,000 brick a week, twice the output of the largest existing brickworks in Great Britain, will be turned out by the projected plant. The materials are placed, practically dry, in a patent molding machine. The molding is effected by vibration without pressure, so that the brick is absolutely homogeneous and is free from air cavities and other defects.

Portland Cement in the United States

By Robert W. Lesley
Consulting Editor of CONCRETE
First President, Portland Cement Association, 1902

We think of portland cement as having been invented 100 years ago, but look in vain in American history to find a steady and prolonged development in the production of the material all through the century. The development and growth of the portland cement industry was closely interwoven with, and has been a gradual outgrowth of, the natural cement industry, since, to a considerable extent, many of the same natural deposits of raw materials have been used for both these finished products, and the two entirely different results have been a matter of refinement and of selection and of means of combination to produce the standardized portland cement of the present day.

These cements have served as a binding agent in more ways than one. Cement may be said to have knit the whole nation together, for it is in the perfection of transportation that a nation is really united. To effect this unification of the nation, we have had to develop systems of both canals and later on, railroads, in the construction of both of which cement has played an important and very necessary part.

The first great public work of this country was in the construction of the canals in the early decades of the last century. The history of the manufacture of cement in the United States in its incipient stages almost synchronizes with the history of the development of these early artificial waterways.

When the Erie canal was built, hydraulic mortar was a prime necessity, and out of this necessity grew the discovery of cement making materials at Fayetteville, N. Y., in 1818; and near Lockport, N. Y., in 1824. Natural cement industries sprang up in both these sections. The construction of the Delaware and Hudson canal, from Rondout to Honesdale, Pa., brought about the discovery of the Rosendale district, where, 30 years ago, nearly 3,000,000 bbls. of natural cement were being produced annually. This district was first opened in 1826. The Louisville district owes its discovery to the Government canals, begun in 1829 for the purpose of facilitating navigation around the falls of the Ohio at that point; and in 1895 nearly 2,000,000 bbls. of natural cement were made in that district. When, in 1836, a canal was to be built to connect the coal and mountain district of Maryland with tidewater at Georgetown, necessity, again the mother of invention, led to the discovery of cement making materials at Cumberland and at Round Top, the centers of what came to be known as the Potomac cement district. The materials for a well-known cement of the west, produced in Utica, Ill., district, was discovered in 1838 for the purpose of supplying cement for the Illinois and Michigan canal, for which locks and bridges were being constructed. To the building of canals was due construction of cement works at Balcony Falls, Va., this material going into the construction of the Richmond and Alleghany canal; while the works at Siegfried, Pa., the pioneer mills in the great Lehigh Valley district, became necessary to the construction of the Lehigh canal. In addition to these, there were large mills at Milwaukee, and works at Cement, Ga. All these mills produced in the year 1894 nearly 8,000,000 bbls. of natural cement. It is interesting, as indicating the beginning of competition at that time, that ten years earlier, in 1884, with about half the production, this smaller output brought as many dollars as the double quantity in 1894.

The man in the street is likely to think that the trail of the uses of cement winds backward through the years to the works of the early Romans; but, as a matter of fact, the Roman mortars were not cement at all as it is now understood, but were mixtures of slaked lime and pozzolana, a volcanic dust which was found in large quantities in Italy. It was not until toward the 18th century that the true principles of hydraulic cement were discovered by Smeaton, who, preliminary to the construction of the Eddystone lighthouse, in England, made a number of experiments and laid down the principle that limestones yielding from 15% to 25% of residue when dissolved in hydrochloric acid will set under water. This proved to be the key to the whole industry. These argillaceous or clayey limestones he denominated hydraulic limestones, and from this principle came the modern hydraulic cement.

Natural cement, much like the Rosendale, Lehigh, and Cumberland cements of this coun-

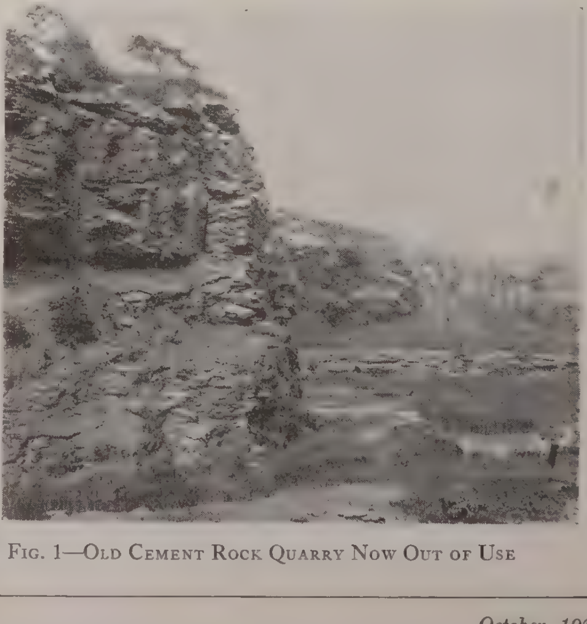


Fig. 1—Old Cement Rock Quarry Now Out of Use

try, was first made by Joseph Parker in England, in 1796. Parker discovered what he called "Roman cement," based upon the calcination at low temperatures of nodules of stone which he found in England. It was practically the first cement of commerce, and gave excellent results. This was followed by the work of Sir William Pasley, who made an exhaustive series of tests; while Vicat was working in France on the scientific or chemical side of the subject. While these experiments were going on, Joseph Aspdin, of Leeds, in 1824, patented portland cement, as a result of his work in the field. There is an interesting parallel between developments in portland cement in America and in England. As the growth of the natural, or Roman, cement industry in England was more rapid than that of the portland cement industry, so was the production of natural cement far ahead of the portland cement industry in this country. It was not until many years after Smeaton's discovery, or even after Aspdin's patent, that the portland cement industry figured extensively in commerce, either in England or in America. Portland cement was given its first great engineering distinction when John Grant, the great English engineer, decided to use portland cement in the construction of the London drainage works, and his two papers on this project, published by the Institute of Civil Engineers of Great Britain, may be said to be the beginning of scientific literature on the subject of cement testing, and the first to put portland cement to the front as a material upon which engineers could rely to the fullest extent.

In this country, we made the natural cements similar to the Roman cement of Parker, and also the portland cement of Aspdin. The laminated cement rock of the Lehigh region, from which, among others, natural cement was made, was calcined in open kilns, like lime kilns, a moderate heat only being used. The product was then ground, put into barrels, and was ready for shipment as natural cement.

Many of the rocks used in the manufacture of portland cement are very similar to those from which natural cement is made, except that they have a lower lime content. The various layers in the natural rock may vary in size or stratification, so that the lime, alumina, or silica may not be in position to combine under heat, or there may be too much of one ingredient, or not enough of others in close proximity to each other. In making portland cement in the Lehigh district in the early days, these rocks properly proportioned, were accordingly ground to an impalpable powder, the natural rock being broken down and the laminae distributed in many small grains. This powder was then mixed with water, and made into a new stone in the shape of brick, or block, in which all the small grains formerly composing the laminae of the original rock are distributed and brought into a close mechanical juxtaposition. The new rock thus made was put into kilns with layers of coke, and was then calcined at temperatures around 1400 Centigrade. The clinker as it came from the kiln was then crushed and ground to an impalpable powder. This was the portland cement of commerce. Portland cement may be made from other materials, such as chalk and clay, limestone and clay, cement rock and limestone, and marls and clays. In every case, the principle is the same, the breaking down and redistributing of the materials so that the fine particles may be in close mechanical union when subjected to the heat of the kiln. This explanation ties these two distinct developments of natural and portland cement into one.

The first American portland cement plant was that of the Coplay Cement Co., of which David O. Saylor, of Allentown, was the president. The plant was established about 1865, to make natural cement. Saylor, who was a man of indomitable energy and great ability, producing a natural cement of excellent quality, made up his mind in the early seventies that he could make portland cement in this country, and his first experiments are most interesting. He knew that by burning to incipient vitrifaction the rocks of his quarry he could make a cement that at short periods showed tensile strains equal to the imported portland, but he found this cement would crumble away as time went on, owing to the variation in the raw material. By sheer force of his native ability, Mr. Saylor studied out and successfully applied to the Lehigh rocks the principle above mentioned as governing the production of portland cement, and took out one of the earliest patents for manufacturing portland cement granted in this country.

While this experiment was being carried on to success in the Lehigh region, and the foundations were being laid for the large industry that now exists, other works were started. Early in 1875,

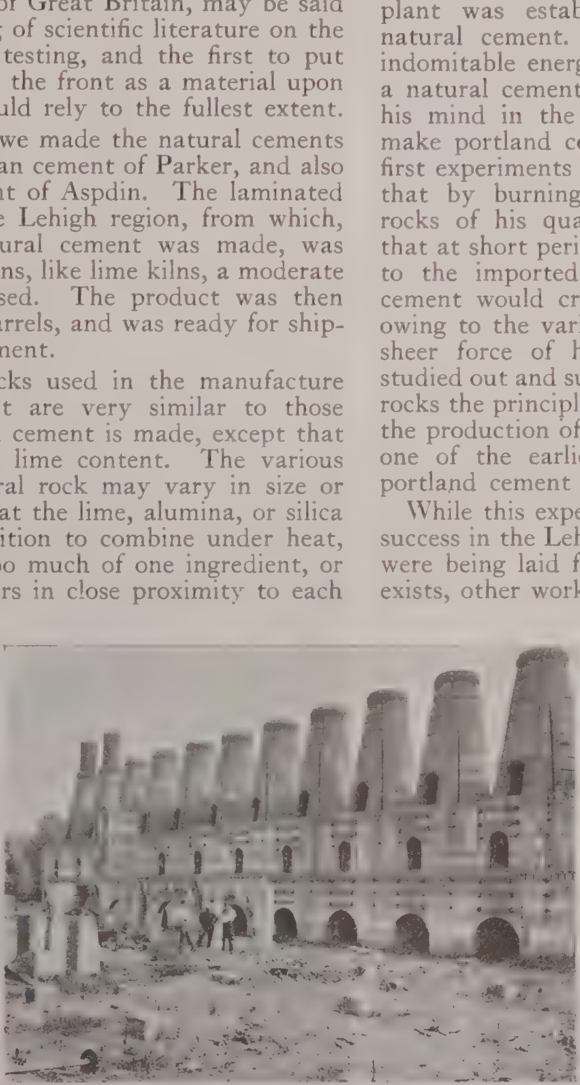


Fig. 2 (Left)—A Row of Old Intermittent Kilns at the Old American Cement Co.'s Plant at Egypt, Pa.

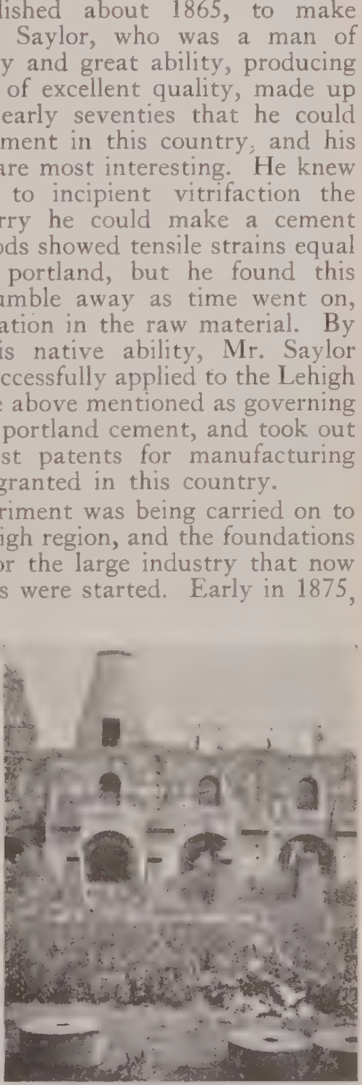


Fig. 3 (Right)—One of the Earliest VerticalKilns Built in the Lehigh Cement District

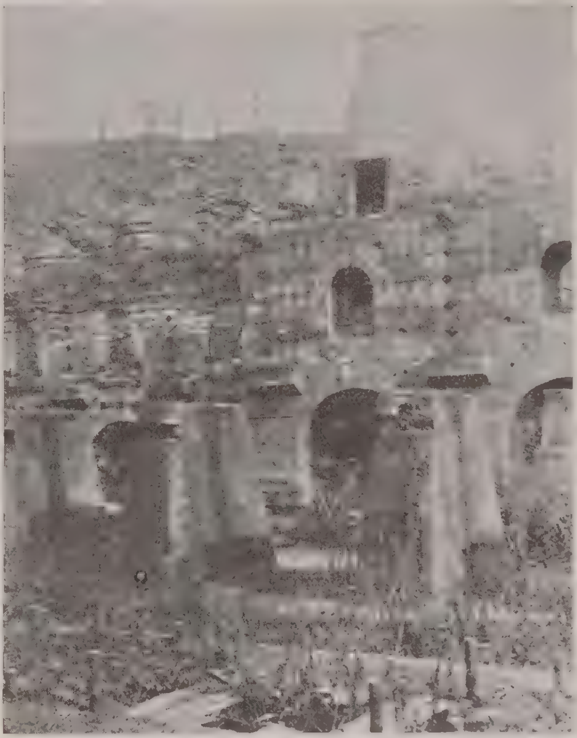


Fig. 4—Close-Up View of Early Cement Kiln

manufacture in a small way was begun by Shinn, at Wampun, Pa., near Pittsburgh, using limestone and clay. At South Bend, Ind., Thomas Millen, an Englishman, found a white marl and a blue clay which resembled in composition, though not quite in form, the materials used for cement making in England. He started a small works there in 1877. Millen later transferred his field operations to New York state. The Rockland, Me., lime is well known as one of the best and purest in the country, and it was but natural that the portland cement industry should seek a lodgment in that field. The Cobb Lime Co., an important concern there, started works in 1879, but the product was too dear for commercial success and the plant was closed down. For similar causes, a like fate overtook the National Cement Co., which was established by S. D. Coykendall and others on the Hudson, in the well-known Rosendale district. Thus it may be seen that out of the five original works started in this country prior to 1881, two were failures, and certainly the industry, with this percentage of loss, did not offer a very encouraging outlook to the investor. At this period, the foreign portland had the market exclusively, and there seemed little likelihood of growth for the American industry.

Patents were necessary to enlist capital in the earlier enterprises, and many of the earlier works were founded on them. The great difficulty in all the American enterprises seemed to be the cost of getting the raw materials into powder, then into paste, then into bricks or blocks, and then into the kiln with a sufficient economy to compete with the lower-priced European labor. About 1884 and 1885, patents were taken out by James M. Wilcox, E. J. Smedt, and Robert W. Lesley, for the purpose of mixing liquid hydrocarbons with the paste. In this way a "slurry" was made, which when compressed into balls or eggs, could be put at once into the kilns, and thus many of the intermediate steps used in Europe were dispensed with. These processes which were used in the works started by the American Cement Co., at Egypt, Lehigh County, Pa., under the management of John W. Eckert and Robert W. Lesley, were based upon the use of the by-products of the manufacture of coal gas as a binder for the raw material during calcination, but with the introduction of water gas and the consequent advance in the price of coal tar, the processes were abandoned and other methods adopted. The American company is still operating under the title of Giant Portland Cement Co. Its original mill, the Egypt Cement works, started in 1884, at Egypt, Lehigh County, Pa., was superseded by other large works under the same management, and in the early days of the industry the company was one of the largest, if not the largest, of the American manufacturers.

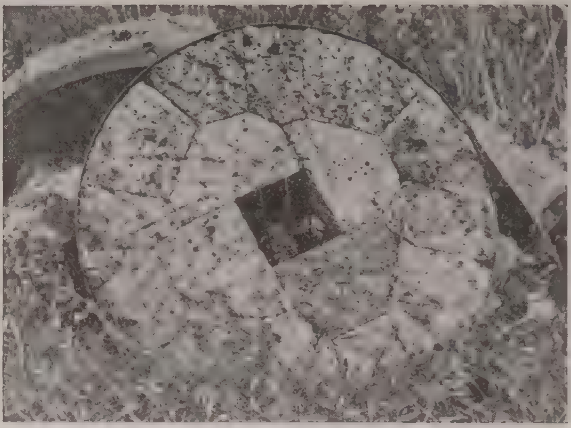


Fig. 5—Old Mill Stones Used in Grinding Cement Materials in Early Days

While these methods of saving the intermediate processes of drying were being used, other inventions by Mathey, Navarro, and Ransome in the same direction gave rise to the establishment of the Atlas Portland Cement Co., which became another great producer of cement. These processes, based originally on the calcination of the crushed raw rock by oil in revolving kilns, were at first unsuccessful, the cement proving unre-

Fig. 6—Some of the Old Mill Stones Used in Grinding the Cement in the Plant of the Old American Cement Co.

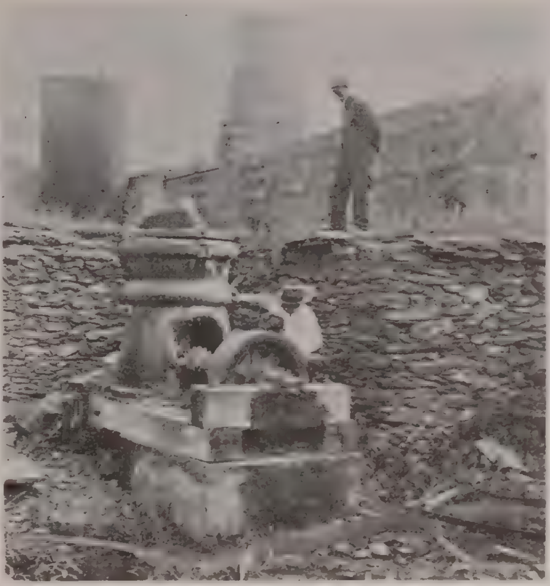


FIG. 6—GATES CRUSHER WHICH WAS IN ITS TIME CONSIDERED THE LARGEST ROCK CRUSHING PLANT IN THE CEMENT INDUSTRY

liable for the same reason that gave Saylor trouble originally, as the raw materials were fed into the kiln as small pieces of rock instead of being ground to powder. Subsequently, however, improvements were made whereby the material was ground to an impalpable powder and slightly moistened before being run through the kiln, and the cement made in this way has proved successful, especially in later days when pulverized coal has been substituted for oil as a fuel, as a result of the work of Hurry, Seaman and other investigators.

To return for a moment to the pioneer work of American portland cement manufacture. It was about 1872 or '73 that David O. Saylor, in association with Esias Rehrig and Adam Woolever, of Allentown, Pa., came to the conclusion that a portland cement should be made from the natural cement rocks of the Lehigh Valley, which they at that time were manufacturing into what was known commercially as Anchor natural cement. Mr. Saylor's first idea was that he could take these natural rocks and burn them at high temperatures to incipient vitrifaction, and by grinding that product make portland cement. The first results justified his expectations—the rock did clinker; did resemble portland cement clinker, and when ground and made into briquettes, gave results on the testing machine equal to the best imported brands. He manufactured a large quantity of it, but suddenly found he was doomed to disappointment, for the material, owing to the irregularities in the rock, was not homogeneous, and at long periods the briquettes, pats, and work made with the cement all began to fall away and disintegrate. At that time, he had a large stock of this cement in bins, and was driven to his wits' ends to know what to do with it. He put his brains to work; had analyses made of his rock; found that the analysis was near the portland cement of commerce, and, without anything but his native wit to guide him, ground the raw material into powder, made the powder into brick, sent to England for designs of the kilns then in use on the Medway and Thames, and, after the kilns were completed, actually made portland cement. And, strange to say, when later he came to look at the bins of damaged cement he had on his hands, he took lumps of that material which had hardened in the bins, and by re-calcining to clinker, made excellent portland cement. Cement of this manufacture was exhibited at the Centennial exhibition of 1876, where both portland cements, the Wampun and the Saylor, held their own with the foreign brands then exhibited. Mr. Saylor was assisted in his work by John W. Eckert, a graduate of Lehigh University, who was for many years his manager, and who subsequently, as already stated, became president of the American Cement Co., at Egypt, Pa., in close proximity to Saylor's works. The works erected by Mr. Saylor are still in existence under the name of the Coplay Cement Co., and are large producers today.

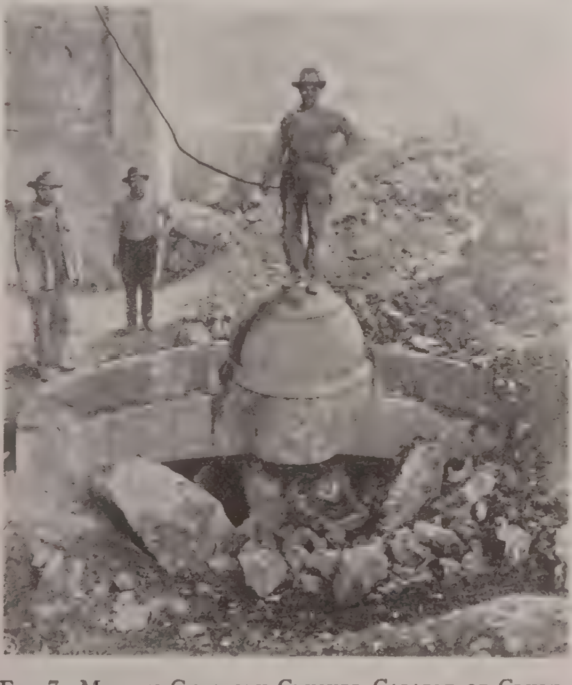


FIG. 7—MODERN GYRATORY CRUSHER CAPABLE OF CRUSHING ANY ROCK FRAGMENTS HANDLED BY THE STEAM SHOVEL IN THE QUARRY

In the Rosendale district of the Hudson, a number of gentlemen undertook to make portland cement out of Fuller's earth and lime, under patents of C. F. Dunderdale. Works were erected, but it was found that the cost was far out of proportion to the price that could be realized, and these works, which were established in 1876-77, were finally abandoned, as were other similar works subsequently established under the name of the Walkill Portland Cement Co., in the same district.

The Buffalo portland cement, of which small quantities were manufactured for a few years along from 1878 to 1885, was due to the discoveries and patents of Uriah Cummings and L. J. Bennett, who were connected with these works, and who found, by selecting the overburned material from the common cement kilns of the Buffalo Cement Co., a material resembling portland cement could be made. The rock, how-

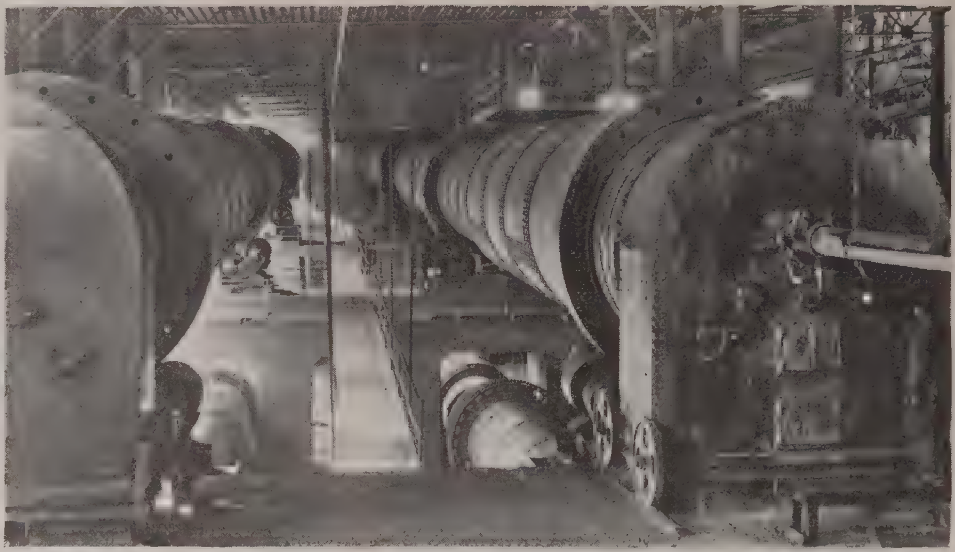


Fig. 8—A Modern Rotary Kiln Installation for Converting the Pulverized Raw Materials into Cement Clinker

ever, was largely magnesian, and for this reason no great quantities of portland cement were made.

As an outgrowth of the patents of J. Murphy and N. Lord, portland cement works were established at Columbus, Ohio, about 1885, for the manufacture of portland cement from slag, lime, and clay. In Texas, at about the same time, the Alamo Portland Cement works were established at San Antonio, and produced cement from an admixture of a natural cement rock an a species of chalk found there. Chicago also entered into the business, and attempted to make a commercial portland cement by importing portland cement clinker from Europe and grinding it with raw limestone to produce a commercial artficial portland cement; while Louisville, not to be outdone, inasmuch as all the other natural cement districts were experimenting with portland cement, undertook, under patents of Anderson and Brice, to make portland cement by calcining at high temperatures, small pieces of magnesian rocks and also by combining lime-, stone and marl and shales for the same purpose. Colorado was not behindhand, and works were established at Colorado Springs, and at Denver, using the sulfate of lime rocks found near Manitou.

All these works manufactured cement practically under the same general process, although of different materials, ranging all the way from natural argillaceous limestones down to mixtures of clay and marl. All of them used the same general form of kiln, such as were used on the Thames and Medway in England, and on the Rhine in Germany; and all of them varied slightly in the character of their grinding machinery. Other portland cement works manufacturing cement under these same conditions were located at Siegfried and Whitehall, Pa.; at Bellefontaine, O.; at San Diego, Cal.; and at Yankton, S. D.

It was at about the same time the American Cement Co. was getting under way at Egypt, and the new experimental works were started on the Hudson by De Navarro and others, when, under the Mathey patents, small pieces of natural cement rocks were roasted in rotary kilns and calcined to incipient vitrifaction at the great heat produced by petroleum vapors injected into the rotating cylinders. The works on the Hudson, by reason of the non-adaptability of the raw materials, proved a failure. The particular forms of kilns were also unsuccessful, but subsequently, by adopting kilns and processes under inventions of Ransome in England, the process of making cement in rotary kilns began, after its removal from the banks of the Hudson to Coplay on the Lehigh, to take on a moderately successful aspect. The calcining of gypsum in revolving cylinders had been done under the Smith process in Philadelphia, with excellent success, and Ransome's process was the application of this theory to another material. Works were established in 1886 on the Lehigh River, Pa., and are today manufacturing millions of barrels of Atlas portland cement per annum. Other works, operating under different methods, but still making portland cement under the rotary process, were established at Whitaker, N. Y., and at Vulcanite, N. J., under the names, respectively, of the Alpha Portland Cement Co. and the Vulcanite Portland Cement Co.

Many of the foregoing reminiscences are from a paper which I presented in November, 1895—29 years ago—before the Boston Society of Civil Engineers. In view of the present (1924) proportions of the portland cement industry, there is a smile at the proud peroration of that paper of three decades ago, "This, roughly speaking," I said, "is the history of the American portland cement industry, which today gives employment to about 2000 men, has 20 works, and manufactures about 800,000 barrels per annum."

For today the American portland cement industry has about 125 mills, employs about *35,000* men (and this in spite of a vast labor displacement by improved mechanical means), and produces (1923) 137,000,000 bbls. annually, with a capital investment of $300,000,000.

Discussion by Richard L. Humphrey, the distinguished engineer, of a paper which the writer presented before the Franklin Institute on the history of the portland cement industry (November, 1898) shows as a statement of the condition of affairs 26 years ago, in how really short a time the portland cement industry has experienced its

(Continued on page 161)

How to Apply Textured Stucco Finishes

Told Chiefly in Pictures

By Samuel Warren
Manager, Atlas-White Department, The Atlas Portland Cement Co.

Many letters of inquiry have come to Concrete *as to stucco finish. "Tell us more about stucco finishes," they say. Last winter, when the Atlas Portland Cement Co. brought out a motion picture film that showed each twist of the wrist in obtaining several very different results in textured stucco, we asked Mr. Warren if he could and would make separate prints in proper sequence from several parts of the film so that* Concrete *could reproduce them for many readers not fortunate enough to see the motion pictures. Mr. Warren was willing, but there were certain difficulties. The motion pictures were clear and sharp, but the separate views which make up the film were "fuzzy." So, yielding to* Concrete's *suggestions, Mr. Warren, who has made a very close study of not only the theory but the technique of stucco application, arranged several series of "still" views to show just how to get a given result. And here they are—part of them; there are too many for one issue of this magazine.*

Mr. Warren has discovered one very important thing about stucco textures which he doesn't explain in so many words in this brief article which accompanies the pictures. The experienced plasterer often makes hard work of the new textures. A novice frequently does better. The plasterer works a good deal with his forearm with a rather stiff and regular motion. In producing textures whose character and charm are in their irregularities, the effect must be produced mainly as a by-product of the motion used in applying the material, and bumps and depressions should not be introduced by subsequent manipulation of the surface or they will almost unconsciously become forced, and they are discovered in more or less symmetrical or geometrical arrangement. Many jobs are spoiled by the regularity of the irregularities. It is the same kind of artistic fault that damns the rock-face block. Mr. Warren says—only half seriously, of course; let the experienced plasterer mix the stucco and the hod carrier apply it. This should at least encourage the new hand at the trade.

As to the quality and structure of stucco—these pictures having to do with finish only—the Standard Recommended Practice for Portland Cement Stucco of the American Concrete Institute is a dependable source of information.—Editor.

Owners of houses are no longer satisfied with just the ordinary old-time stucco finishes, such as the spatter dash, rock dash, stipple, and sponge. They want their house to look different from the house next door. Particularly is this getting to be a problem when, with the rapid growth in the use of stucco, there are many such houses side by side.

With portland cement stucco, there are so many finishes and colors available that there hardly need be two houses with identical stucco finishes at least in any one city. White portland cement in the finish coat gives the many varieties of color and the nature of the material, due to the fact that it is so permanent that it needs no rock dash to protect it, allows you to secure countless textures.

First of all, there are certain points in putting on the stucco that should be watched. A safe mix to use, and it is best to make all coats the same, is one bag of portland cement, 3 cu. ft. (3 bags) of sand, and 5 lb. of hydrated lime. Never make the finish coat any richer than the base coats.

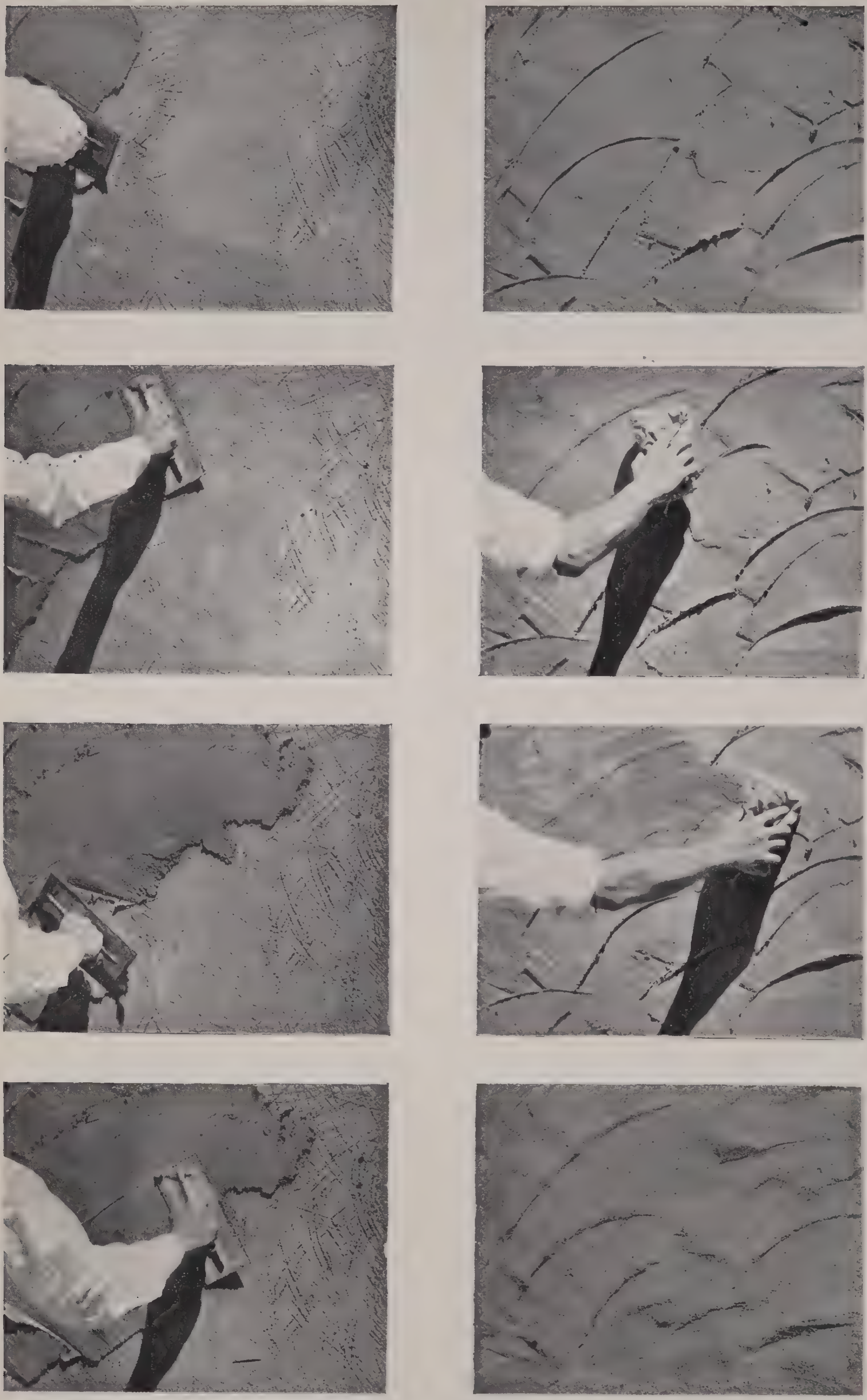
If you are putting the stucco on a sheathed house, always have the sheathing horizontal and never diagonal. Tie the metal lath together at the joints so securely that it is just as though it were one continuous sheet. Never nail the lath flat on the sheathing, unless it is self-furring lath. The purpose of the lath is not just as a rough surface on which to hang the stucco, but a continuous sheet of reinforcing for the stucco.

Don't apply stucco on a very hot windy day, or all the water that the cement needs will be sucked out. Apply the second coat the day after the first, if wanted, but don't put on the finish coat for at least a week. After the second coat is on, keep it wet with the hose for several days. Scratch each coat thoroughly to receive the next.

When applying stucco to brick, concrete block, or hollow clay tile, never cover them with any kind of waterproofing material. Wet them down to prevent too much suction, and apply the stucco directly.

The coloring of stucco is done by using white portland cement for the finish coat. Best color results are secured by using a sand of good color that gives with the white cement the color desired. For instance, a dark-yellow sand and white cement gives a very attractive buff color. Experiment with your local sands and see what colors you can get.

The text of this article is concluded on page 140, following the pictures which show how the work is done (pages 134-139).



How Finish No. 1 Is Obtained

This Finish Shows the Broad Sweep of the Trowel. Ordinarily, the Mason Works Nearly Perpendicularly, Bringing the Trowel from Bottom to Top, and then Coming Down to Smooth the Surface and Remove the Marks Left by the Edge of the Trowel.

In this Finish, the Motion is Roughly Horizontal in Broad, Sweeping Strokes from the Shoulder, and Not the Elbow. The Material Working Past the End of the Trowel Leaves Slight Ridges, and No Attempt is Made to Remove These. The Trowel is Lifted at the End of the Stroke. It is Held at Such an Angle to the Wall as to Leave a Smooth Surface.

The Effect of this Finish is to Secure Differences in Plane Rather than the Sweep Mark.

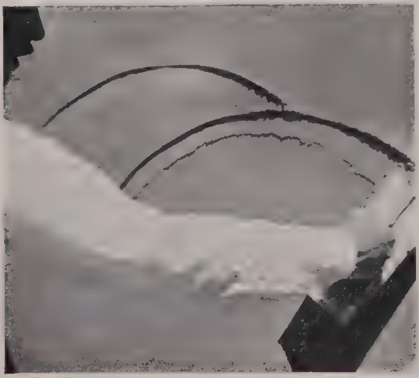
The Finish is Also Attractive When Subdued by Rubbing With a Burlap Bag When Partially Set.

The Last Vertical Row of Pictures in This Set (See Next Page) Shows How *NOT* to Do It

THE PICTURES AT THE LEFT SHOW A VERY COMMON ERROR—TRYING TO PRODUCE A CASUAL EFFECT OF TROWEL MARKS BY AN AFTER TREATMENT — THE RESULT IS HIGHLY ARTIFICIAL AND UNSATISFACTORY. THE PROPER WAY IS SHOWN ON THE PRECEDING PAGE

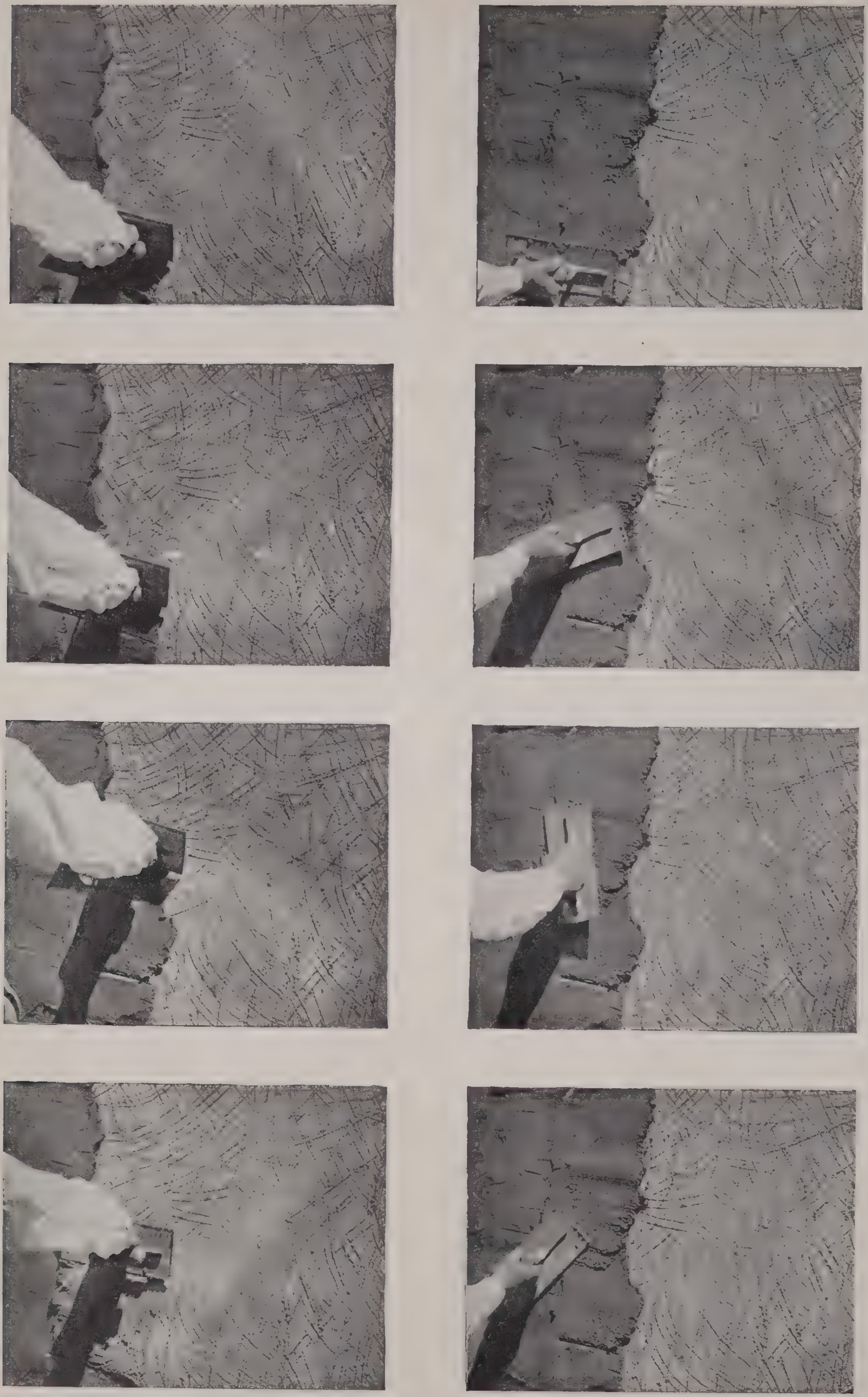
AT THE RIGHT—TOP—IS A DETAIL OF A BEAUTIFUL STUCCO FINISHED HOUSE ON WHICH THE EFFECT IS VERY MUCH LIKE THE RESULT SHOWN IN THE FIRST, PRECEDING SERIES OF HOW-TO-DO-IT VIEWS

AT THE RIGHT—TWO VIEWS, ONE GENERAL AND THE OTHER IN DETAIL, SHOWING THE EFFECT OF A STUCCO TREATMENT VERY SIMILAR TO THAT SHOWN IN THE FOURTH SERIES (NO. 4) ON PAGE 139



How Not to Do Finish No. 1

How the Finished Job Should Look

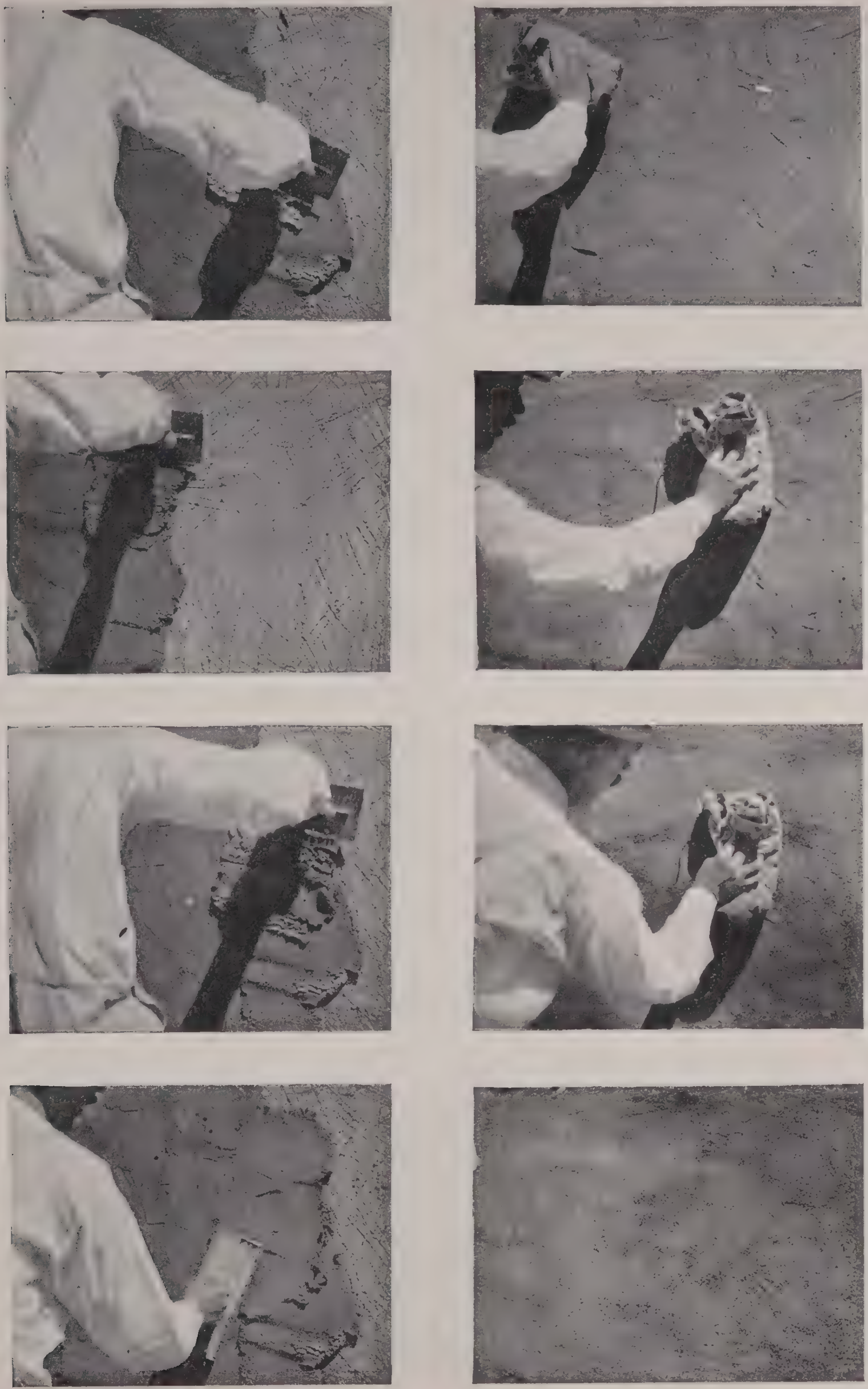


This Finish Gives the Effect of Being Applied Over Rough Rubble Masonry and Gives the Effect so Often Secured in the Old Stucco Over Stone of Colonial Pennsylvania.

The Effect is Secured by the Manipulation of The Finish Coat Only. the Finish Coat is Applied in Irregular Thickness, but the Variations in the Thickness Should Not Be More Than One-Eighth Inch, or a Quarter at the Maximum. The "Lumps" Should Be Roughly Horizontal to Give the Effect of Underlying Courses of Stone. Care Must Be Taken to See That They Average Horizontal, As the Mason Will Usually Give Them a Slight Pitch to the Right. Their Size Should Correspond Roughly to the Size of the Projection of a One-Man Stone. Major Irregularity Should Be Roughly Worked Out with the Trowel, and After Setting for an Hour or So, the Surface Should Be Vigorously Rubbed with a Burlap Bag.

No. 2 Gives an Effect Like Plaster Over Rough Stone Masonry

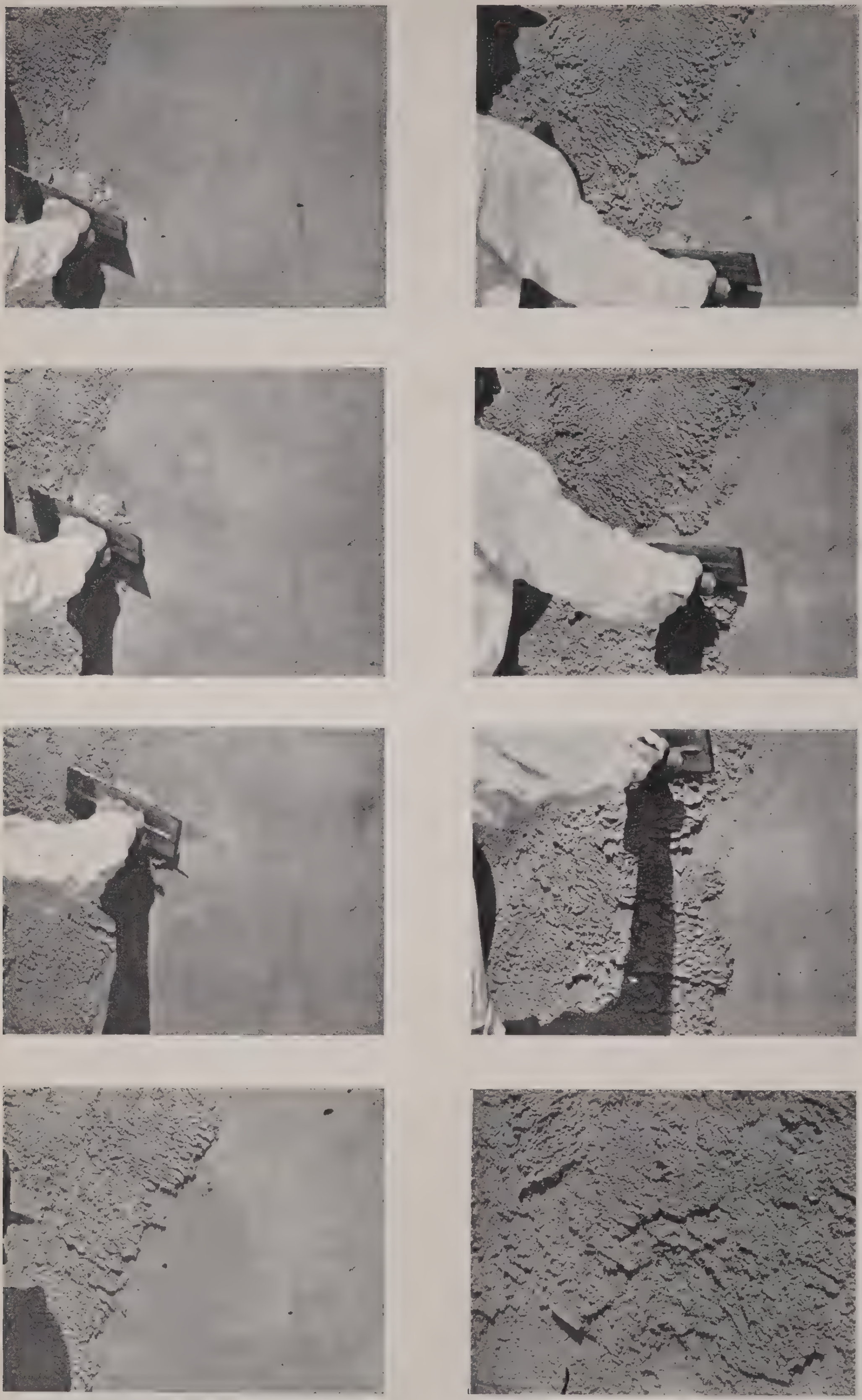
This Shows the Final Work on Finish No. 2 —Begun on Previous Page



The Burlap Bag Rubbing (Finish No. 2) Takes Off the Gloss of the Trowel

This Finish is Effective in its Strength and Freedom of Application, and is Susceptible of Many Variations. The Motion of Application is from the Bottom Up. A Full Trowel of Material, Holding the Trowel at a Sharper Angle to the Wall than Usual, is Given a Free, Powerful Stroke, so That the Mortar Is Spread Along a Length of Several Feet. At the End of the Stroke, the Trowel is Lifted. Holding the Trowel at the Sharper Angle Tears the Material As It Is Applied, Giving the Rough Texture. Spots That Are Not Covered at the First Stroke Are Covered By a Complete New Sweep, Rather than By a Small Amount.

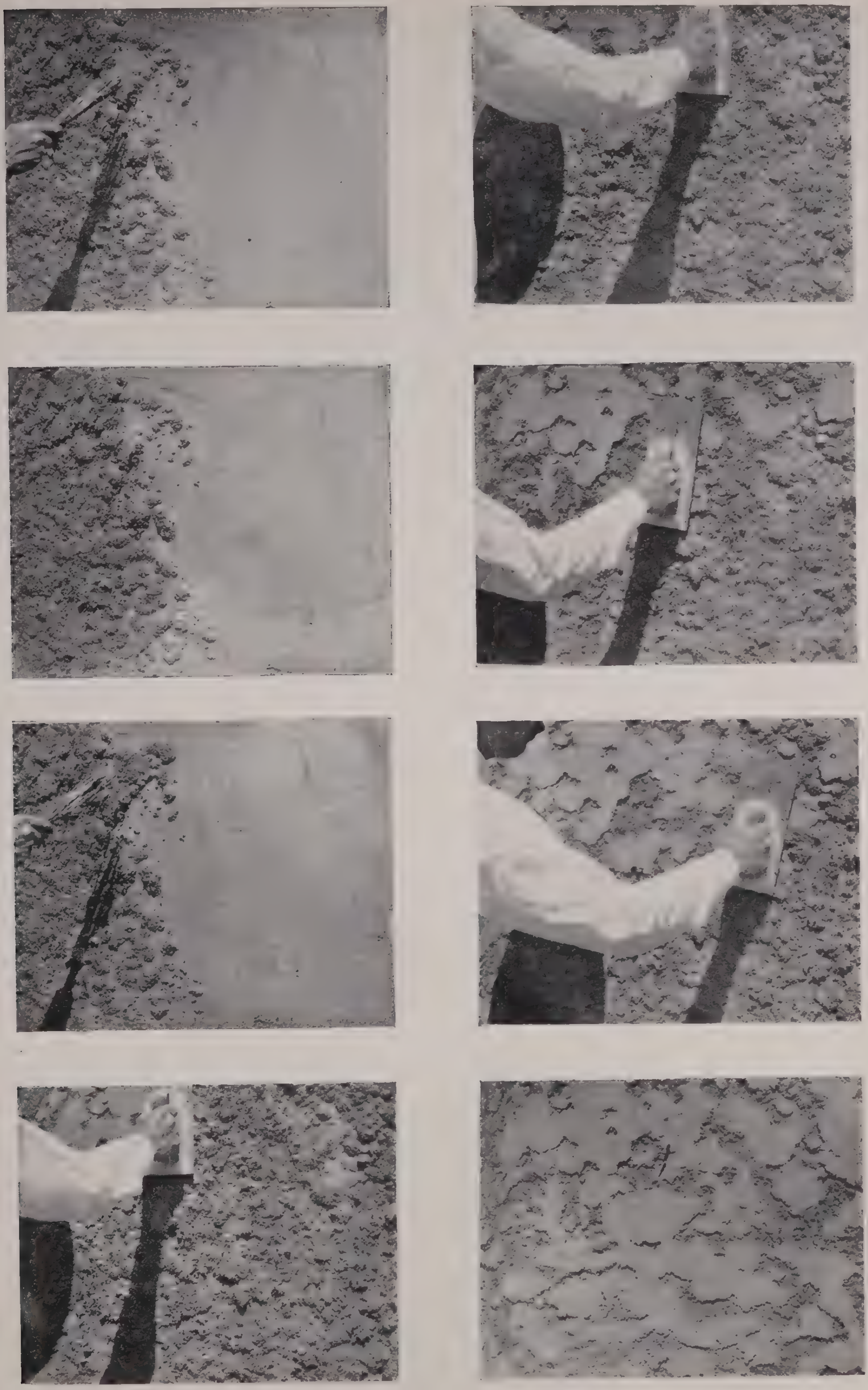
It Is Sometimes Useful to Give the Base Coat a Cover Coat of the Finish-Coat Mortar, and Apply the Texture Over This While It Is Still Soft.



This Finish, No. 3, May Be Given with Many Variations

Over the Base Coats a Thin Layer of the Finish Coat Mixture Is Applied, Followed Immediately by a Spatter Dash of the Same Mixture Thrown on With a Whisk-broom or a Bundle of Twigs. Before This Has Set, the Projections Are Lightly Troweled Down With a Steel Trowel Held Almost Flat Against the Surface.

An Attractive Polychrome Effect May Be Obtained By Applying a Thin Layer of the Finish Coat in One Color and Then Spatter Dash in Another Color.



This Finish, No. 4, May Be Applied to Give Two-Color or Two-Tone Results

The Texture of the Stucco on the House Shown at the Left Is Rough—This Roughness Is Pleasantly Subdued by Distance and the Result Very Beautiful among the Trees

If the proper colored sands are not available, use a white or light-colored sand and mix with them colored pigments. These can be secured from many reliable firms, but be sure that they are intended for cement use, for many of the ordinary oxides are not permanent when mixed with cement. Usually from 2 to 5% will give enough color (2 to 5 lb. of color per bag of cement), but never use more than 10%. When using pigments in order to get a uniform color, it is best to weigh out the amount of pigment required for each bag of cement and put it into little paper bags. Screen the cement and color together thoroughly before adding the sand. If not, the water is likely to make the color collect into solid balls that are hard to break up and leave streaks in the wall where the trowel cuts them.

The technique in securing different textures is not easy to explain, but the pictures on the following pages should show how to go at it. Look at them carefully and then experiment. It is just a trick of the wrist. No special tools, just the ordinary plasterer's trowel and perhaps a burlap bag.

These pictures show several types of textures (others in this series will be shown in a later issue). These are just suggestions of some that have been developed. Experimenting will show you how many others can be secured. Try them out. It means more widespread use of stucco, as it is so much more interesting.

Make the size of the texture correspond to the distance from which the house is usually seen. If the house is usually seen from a distance of 100 ft., then the texture should be coarse enough so that it can be seen at that distance, but if the house comes out to the sidewalk, make the texture much finer.

Below—the Authors—Mr. Warren, at the Left—James Williams, Another Atlas Man, at the Right. This Picture Was Not Intended for Publication in this Series, but "Concrete" Uses it as Some Measure of Proof that this How-To-Do-It Feature Article Really Originated with Men Who Did the Job

The Origin of Portland Cement

The Development of the Industry in Great Britain

Abstracted from *A Hundred Years of Portland Cement, 1824-1924*, by A. C. Davis, and from a paper prepared by the Associated Portland Cement Manufacturers of London.

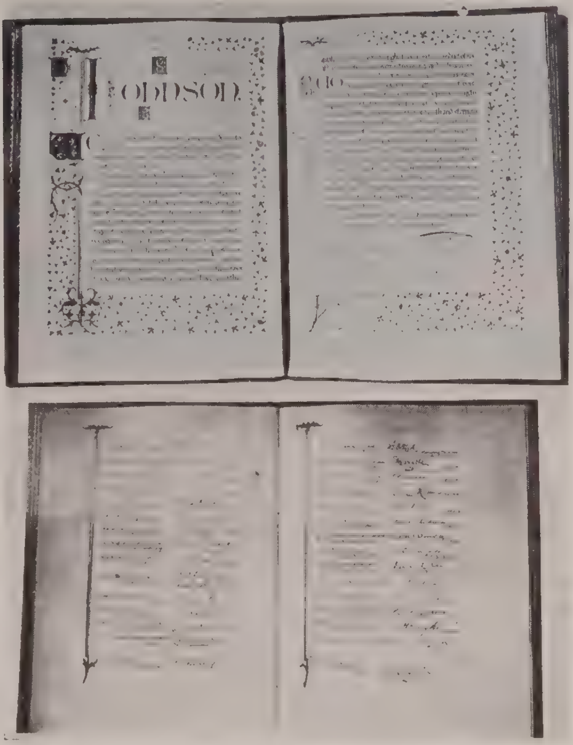


Fig. 1—Copy of a Testimonial Presented to I. C. Johnson on His 100th Birthday by the Cement Manufacturers of Great Britain

It is probable that Joseph Aspdin, knowing little or nothing of chemistry and guided only by impirical rules was able, by virtue of his long experience,—his son William having stated that he produced his cement as early as 1811 although he did not patent it until 1824—to produce a cement of a fairly reliable character but that even he, himself was not fully aware of the exact proportions of the different ingredients contained in the cement he manufactured. In any case, he kept his process a close secret—allowing no one but the workmen to enter his premises and himself taking part in the loading of every kiln strewing between the layers different materials, such as sulfate of copper, sulfate of iron, bone ash, iron slag, etc.

It might appear from Aspdin's silence on this essential point and the fact that prior and subsequent to the issuing of his patent, others had experimented with mixtures of argillaceous and calcerious substances, that Aspdin was not the actual originator of the class of cement which is so widely used today under the name of portland —especially as the manufacturer did not make any great headway for a number of years. All doubt on this point however is set at rest by the fact that as early as 1825 he established a factory at Wakefield near the bridge over the river Calder where he produced this cement. Another works, which still exists and was until recently working, was erected in Ings Road on a site not very far from the original one.

In the same year that Aspdin established his works at Wakefield, (1825) Frost opened a works for the manufacture of his cement on the Thames at Swanscombe, Kent. These works were run by Frost until 1834 when they were acquired by John Bazley White, who had been in partnership with Mr. Francis. Later, his successors, John Bazley White & Sons, when the merits of portland cement began to attract general attention, competed with Joseph Aspdin's son William in the manufacture and sale of the new material. Messrs. J. Bazley White & Sons were successful in making a good cement of a similar character by a mixture of chalk found on their own premises with the blue clay from the River Medway, and no doubt much of their success in this direction was due to the researches and experiments which were carried out by I. C. Johnson who was at that time manager of their works at Swanscombe.

In a pamphlet written by Mr. Johnson and published in the year 1909 that gentleman claims to be the inventor of portland cement but his claim will hardly bear investigation and has not been acknowledged by other writers on the subject. On the 28th of January 1911, Mr. Johnson attained his 100th birthday and was presented with a silver plate and a testimonial signed by the various cement makers of the United Kingdom. This testimonial only acknowledges Mr. Johnson's share in the *improvement* of the manufacture.

Building of Aspdin's Folly

A specimen of the work done with the cement William Aspdin manufactured is still to be seen on Windmill Hill at Gravesend where he purchased land and commenced building an elaborate house, which he called Portland Hall. Carrying out his somewhat ambitious plan, however, proved to be such an expensive matter that he had to stop when the building was little more than one-third up and sell out at a very great sacrifice. The accompanying reproduction of the architect's sketch shows

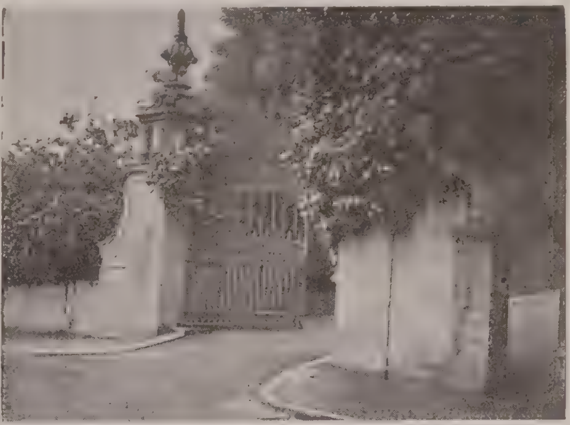


Fig. 2 — Fntrance to Portland Hall, Gravesend, England, Built by William Aspdin, 1852

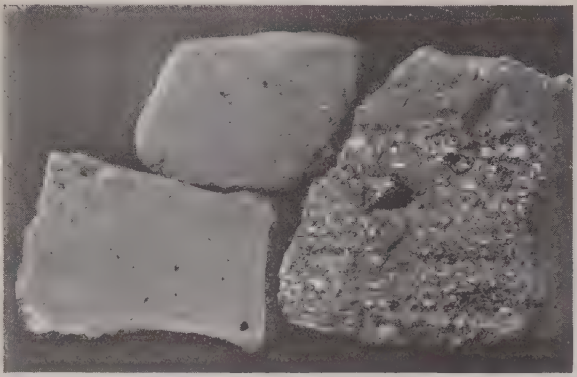


FIG. 3—EARLY SLURRY FROM DRYING BACKS BEFORE CALCINING

the building as it would have been if completed. The partially completed building subsequently became known as Aspdin's Folly but the greater part of it has been pulled down since, and that still existing forms part of a private dwelling house. The walls he built surrounding the property are still standing and an accompanying illustration shows some of the ornamental pillars in this wall. The wall and pillars are built of brick covered with a thick coating of cement and aggregate of which the elaborate capitals of the pillars are also made. This work was probably done about 1855 or 1860 and it will be noted that some of the pillars with their artistic capitals are still in an excellent state of preservation, while others have become considerably dilapidated.

GROWTH OF THE INDUSTRY

In the early days of its manufacture, portland cement appears to have been used mainly for stucco work, and owing to the irregular and unreliable results obtained, it was not much in favor with engineers for construction purposes.

It was an interesting episode in the early days of portland cement (about 1825) when Sir Robert Peel determined to propose to his government that a tax should be imposed on the cement stone used in the manufacture of Roman cement, as he feared the supplies would become exhausted. When William Aspdin heard of this, he wrote to Sir Robert Peel intimating that there was no necessity for his anxiety as an article far superior to Roman cement was being manufactured. To prove this, Aspdin waited on Sir Robert Peel with samples, and obtained a reply to the effect that he was much satisfied with them, and in consequence the proposed tax was abandoned.

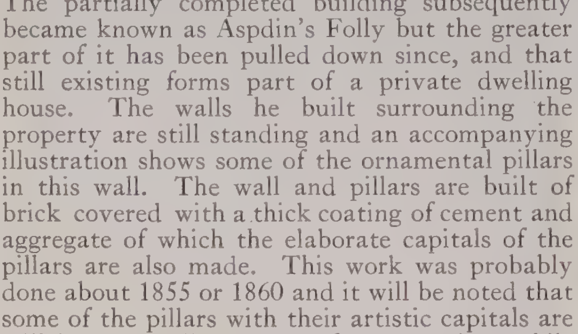


FIG. 4—BLOCK OF CONCRETE EXHIBITED AT THE GREAT EXHIBITION AT HYDE PARK IN 1851 BY J. BAZLEY WHITE AND BROS.

It was just after the first half of the 19th century that improvements in the manufacture of portland cement, through an increasing knowledge of the chemistry of the subject, were beginning to bring this material more into favor with engineers to the gradual displacement of the Roman cement, although this latter, being particularly suited to some purposes, continued to be manufactured to a more limited extent.

The manufacture of portland cement was still carried on in a very crude manner by "rule of thumb" but experience, improvements in machinery, and a gradual realization of the fact that the manufacture of cement is essentially a chemical industry, were causing a steady and increasingly rapid growth of the industry.

There is still preserved at White's factory at Swanscombe a large block of concrete, made with its portland cement which was shown at the Exhibition at Hyde Park in 1851. This concrete consists of stones embedded in a mixture of fine aggregate and cement. The cement and fine aggregate appear to be in the proportion of 1:3 while in the total concrete, the proportion would be about 1:9.

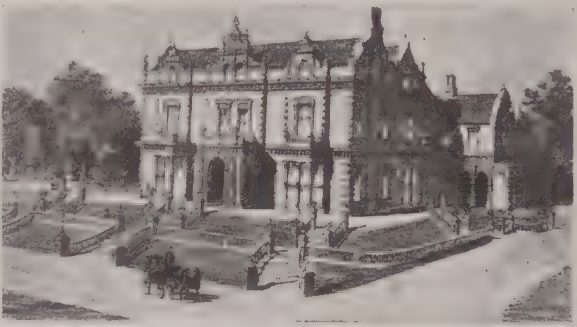


FIG. 5—COPY OF ARCHITECT'S DRAWING OF PORTLAND HALL, WHICH WILLIAM ASPDIN COMMENCED TO ERECT AT GRAVESEND

Numerous factories sprang up, the presence of ample supplies of chalk and the excellent alluvial clay of the Medway, materials which were found to be unsurpassed for the manufacture of portland cement, offering strong inducements to the manufacturers to establish their factories in the Thames and Medway districts. These districts have come to be known as the cradle of the industry.

The handicap which the English manufacturers met with, due to the custom which existed of every engineer drawing up his own specification for cement, has been largely overcome as the result of the publication of the British Standard Specification for portland cement in December, 1904. The most far reaching and important development of the portland cement industry in England was the amalgamation of the great majority of the large works on the Thames and Medway which took place in 1900. This amalgamation of the resources and capital of so many large concerns was immediately followed by an immense development in the scientific research into the properties of, and improvements in the manufacture of the product.

Some Pioneers in the Cement and Concrete Industries of Great Britain

By Frank Jay

In a brief retrospective review it is impossible to mention all those who have been pioneers of more or less value to the industries of concrete, cement and artificial stone. There have been many faddists and failures. The industries have passed through many changes and vicissitudes. Many fortunes have been lost and won and many reputations shattered and broken as well as made.

One of the oldest and best known inventors and patentees of concrete and artificial stone was the late William Boutland Wilkinson of Newcastle on Tyne who was born about 1818 and was in due time apprenticed to the trade of a plasterer. The writer has seen some of his early work in artificial stone, notably, an ornamental balustrade in the garden of a mansion in Northumberland which, notwithstanding its age of over 70 years is as good now as when first molded and erected. Mr. Wilkinson was one of the first users of the new true portland cement in the north of England and recognized its value and possibilities from the first. He was in reality the inventor of concrete paving, both in situ and cast forms. His paving materials at first consisted of Roman cement and what is known in the locality as scoria, namely the fused gas retort firebrick and hard clinker. These he broke up be hand and hammer labor, a rather tedious and costly process.

After a time, Wilkinson invented a hand machine to break up his aggregates and later improved it by using steam power. He could have justly claimed to have invented the forerunner of present day stone crushing machines, although he did not do so. Beyond a doubt he gave some ideas to those who did.

The supply of scoria, a material that is extensively used in Newcastle on Tyne and neighborhood, for all kinds of concrete work being inadequate for his requirements, he obtained the spalls and waste from coral granite quarries and broke them up and graded them in different sizes, using the ½-in. size down to dust for paving and artificial stone work, the larger size being used for heavier work. Recognizing the coming value of the waste material, quarry owners set up crushing machines and screens at their quarries and in this manner gave birth to the enormous trade that now exists in granite chippings of all grades and sizes. Here again, Mr. Wilkinson was the pioneer of an important industry.

The first paving laid in situ with granite chippings and portland cement by Mr. Wilkinson was at Benwall Towers. The writer has seen some of the examples of paving laid by Mr. Wilkinson using scoria and granite chippings, which are in use at the present day and can testify to the excellent wearing qualities and durability making all due allowance for the wear and tear of time.

Reinforced Concrete

On October 27, 1854, Mr. Wilkinson left at the patent office his specifications for the invention of improvements in the construction of fireproof dwellings, warehouses and other buildings or parts of buildings, including staircases, pavings, etc. The concrete floors were to be reinforced with wire rope and small bars embedded below the central axis and in this, he was the first Englishman to conceive the idea of reinforcement in concrete.

Following the granting of his patent on April 28, 1855, "Wilkinson Patent Granite Concrete" soon became famous through Great Britain and the continent of Europe. The first example of sidewalk paving was laid in 1873. At least that is the earliest known record in print, because Mr. Wilkinson first filed records of his contracts and jobs at that date.

Another old pioneer of the concrete industry was Peter Stuart, the founder of the well known firm of Stuart Granolithic Stone Co. Mr. Stuart like Mr. Wilkinson was apprenticed to the trade of plastering and in due time became his own master. He added concrete and cement work to that of plastering and made several improvements in the methods of handling them. A patent was granted him in 1881 for his granolithic stone.

Mr. Stuart's improvement in the matter of paving was to do it in two courses or layers, the first or bottom course being composed of ordinary concrete of 1:4 and the top or finish coat of cement and Scotch granite chippings proportioned 1:2, the surface being finished after troweling, with a uniform imprint by means of a studded roller machine. The patentee claimed his invention gave greater strength to the paving and was more economical than Mr. Wilkinson's method which was one solid coating or layer of not less than 2 in. laid directly upon a 4-in. bed of broken stone, brick or hard base which had to be broken and left as true and even as possible to insure a proper and uniform thickness of the granite concrete paving materials after making allowances for what ran into and mixed with the foundation.

Mr. Stuart, on the other hand, was not precise with his broken brick and stone foundations, it was broken up roughly and left fairly level and uniform to receive the first course of concrete, his contention being that the cost of a little extra thickness of concrete was less than that of Wilkinson's special way of treating the foundation. Thus Wilkinson was the champion of the one-course work and Stuart the champion of two-course work. Mr. Stuart, who was called the Granolithic King, introduced granolithic into Germany and the Kaiser made use of it when he converted the crumbling rock of Heligoland into an impregnable fortress.

It is singular that both these two pioneers of the concrete industry lived to be about the same age. Mr. Wilkinson was in his 84th year when he died. Mr. Stuart died at the age of 86 years. The names and achievements of William Boutland Wilkinson and Peter Stuart will stand out prominently when the complete history of concrete and its kindred industries, is written up for posterity.

The Portland Cement Association

What It Is and Does

Of the 1800 trade associations and related organizations in the United States, it is probable that none carries on intensive educational and promotional work more thoroughly than does the Portland Cement Association. With its purpose well expressed in the slogan, "A national organization to improve and extend the uses of concrete," it is reaching all of the United States and Canada with its many publications and advertising and is in personal touch with practically every part of the United States and British Columbia through its field representatives.

In 1902 at a time when the industry had just begun to expand rapidly, a little group of cement manufacturers met in New York City to discuss problems of common interest. About a score of plants were represented. From that small beginning the present organization has been developed. The members soon found that by spreading information about the uses of cement in making concrete structures they could do far more to advance their business than by simply discussing manufacturing problems. Thus it has come about that by far the major attention is given to educational and promotional work, although various committees are at all times hard at work on manufacturing problems of interest only to those engaged in the industry.

The Portland Cement Association is in no way concerned with the actual manufacture, sale or distribution of cement. Rather, its forces are engaged in developing a bigger demand for cement, leaving the manufacture and sale of the material entirely to the individual companies.

For carrying on its research—educational—promotional work, the Portland Cement Association has built up an organization consisting of about 430 employes. These are stationed at a large general office in Chicago, at 29 district offices and in the surrounding territory, and at the Structural Materials Research Laboratory in Chicago.

The general office serves as a clearing house for all sorts of information about concrete collected everywhere and made available to association representatives and the public the country over. All publications and advertising are handled at the general office, and general policies are there determined. Various departments known as the Cement Products Bureau, Highways Bureau, Railways Bureau and Structural Bureau specialize in the different fields of concrete construction. Two others—the Advertising and Publications Bureau, and the General Educational Bureau—handle the advertising and the publicity work.

In order to assist with the work of the general office a complete library is maintained at Chicago. In this library there are over 35,000 books, pamphlets, etc. and a subject card index of over 100,000 cards is available. Every year fifteen to twenty thousand inquiries are answered. These inquiries range from a telephone call answered immediately, to researches requiring several days to complete. Library service is offered to anyone interested in concrete.

Each of the 29 district offices, 28 of which are in the United States and one in Western Canada, is in the charge of a district engineer, who, with an appropriate number of field men, keeps in close personal touch with the territory assigned to that district. Through these field representatives the many improvements in concrete work are made known to technical men and builders. Much attention is given to ways of improving the concrete actually being made, and wherever possible, the more extensive use of concrete is promoted, provided such use is really economical. The entire district office force consists of about 275 men, almost all trained engineers, and in addition, such office help as is needed.

The cement manufacturers early realized the need of accurate and complete data concerning concrete, and in 1916 joined with Lewis Institute, a polytechnic school in Chicago, in the formation of the Structural Materials Research Laboratory, which was founded for research in cement and concrete.

From a small beginning, the laboratory has grown until it now occupies space on several floors. Its present staff is made up of about 35 engineers, testers, chemists and assistants under the direction of Prof. Duff A. Abrams. For the past three years, the laboratory has been making standard cylinders for testing at the rate of about 30,000 a year, and many specimens of other types have also been prepared.

Whenever sufficient tests have been made in an investigation to warrant definite conclusions, the results are published as papers before technical societies and in bulletins put out by the laboratory itself. Since the first bulletin on "The Design of Concrete Mixtures" was published, 10 additional ones have been distributed and others are now in preparation.

The chief aim has been to discover the fundamentals of making good concrete, and much progress has been made.

The most important recent investigation announced has been a thorough study of the constitution of cement, made jointly by the U. S. Bureau of Standards and the Portland Cement Association.

An advisory committee made up of representatives of Lewis Institute and of the association determine the policy of the laboratory. The actual problems for investigation are selected by the association's committee on Technical Problems from the many suggested. Of course the research staff works in close touch with the committee.

Funds for all the many sided activities of the association are provided by the cement manufacturers under two heads: general dues and special dues. General dues are used for the maintenance of the general office, the laboratory, and for buying the bulk of the advertising space. These dues amount to eight mills per barrel of cement made. From special dues are paid the expenses of district office operation. They vary in different localities, but average about 1 ¼¢ a barrel shipped.

Membership in the association is of course purely voluntary, but nearly 90 % of the operating companies in the United States are members. In addition, there are 4 companies in Canada having 14 plants, one company in Mexico with a single plant, and one operating 3 plants in South America and Cuba, that all belong to the association. It is estimated that the member companies in the United States represent about 95 % of the total cement producing capacity of this country. Regardless of size, each company has only one vote in association affairs.

Aside from this work leading toward more and better concrete, the association carries on a number of activities for the purpose of developing more efficient and economical methods of manufacture.

For example, there is the work of the Committee on Conservation, which is carried out by a Conservation Bureau. That committee has in charge the investigations leading to improved mill practices. Such matters as the utilization of hot gases from the cement kilns for generating steam, the determination of the best grinding media for use in various types of pulverizing equipment, and the value of certain linings for kilns are representative of the problems attacked.

Then there is a committee on accident prevention and insurance, also represented by a bureau at the general office of the association. It is estimated that in 1923, 16,000,000 lbs. of high explosives were shot off in cement plant quarries. Throughout the entire course of manufacture, a great deal of heavy machinery is required and chances for accidents are many. It is the work of this bureau to promote safety, and its accomplishments through cooperation with the safety organizations of the member company plants have been very real. For instance, in 1923 on the basis of lost time from accidents compared to the man hours worked, a 17 % reduction was achieved—yet industrial accidents the country over increased more than in proportion to the increase in manufacturing activity.

Still another committee is that on transportation. Through this committee, the industry has been able to cooperate effectively with the railroad organizations working for more efficient car movement and to safeguard the rights of the companies as shippers.

All of the promotional and educational work of the association has been based on the idea that through the satisfactory and economical use of concrete, the demand for more cement will be best stimulated. Quality concrete, rather than simply more concrete, has been, and is the aim.

A 15th Century Concrete Bridge

A Concrete Bridge Built Before Columbus Discovered America

The Photograph from Which This Illustration of Early Concrete Bridge Is Reproduced, Was Made in November, 1908, by J. P. H. Perry, Vice President of the Turner Construction Co., New York City. It Is in the Amalfi Valley on the Italian Coast Just South of Naples. According to Local Historians the Bridge Was Built in the 15th Century at the Time the Turks Were Occupying That Part of the Italian Coast, Which Was the Period When the Seat of Authority of the Roman Empire Was in Constantinople Instead of in Rome. The Bridge Is About 6 ft. Wide and Has a Span of About 24 ft. Between Abutments. At the Time Mr. Perry Saw the Bridge It Was in an Excellent State of Preservation and Apparently Was of True Concrete, Probably of Some Early Roman Cement, the Aggregate Varying from Fine Particles to Stone up to 2½ in. in Diameter

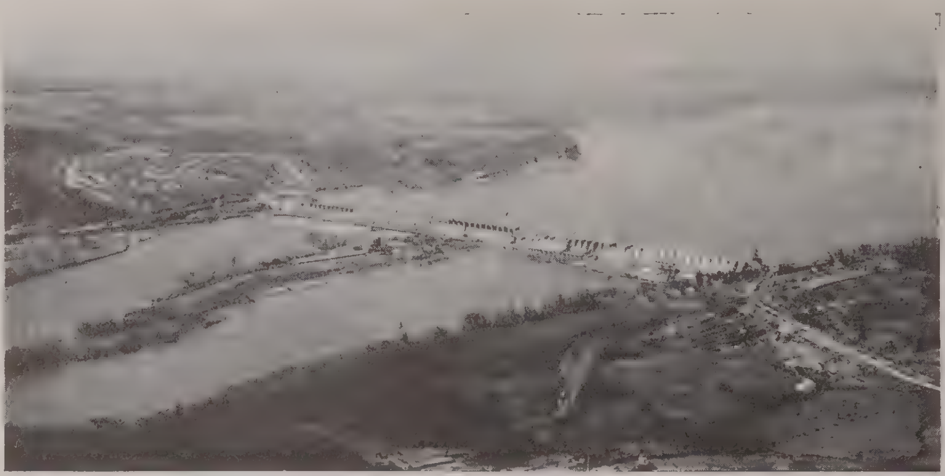


Fig. 1—Airplane View of Wilson Dam. Power House Section in Foreground, Jackson's Island and Spillway Section in Middle, with the North Abutment and Lock Section in the Background. The Form Shops Show on the South Bank of the River, While the Construction Camp, Etc., Shows Clearly on the North Bank Above the Lock Section.

(c) U. Goria

Wilson Dam Nears Completion

Many Interesting Features of Concrete Work

As in the story of the three blind men who observed a passing elephant by their sense of touch, the interesting features in the Wilson Dam depend somewhat upon the viewpoint of the observer. The Muscle Shoals work presents a project, the magnitude of which it is hard for the mind to conceive, even with all the reams that have been written about it. It is big enough so that one may discover a number of extremely interesting features of design and of concrete construction without compassing the whole work. Among these are the large central mixing plant, unusual quantities of concrete handled, intricate form work, care in placing the reinforcing steel, methods of placing the concrete, and the uniform appearance of the concrete surfaces of the completed work.

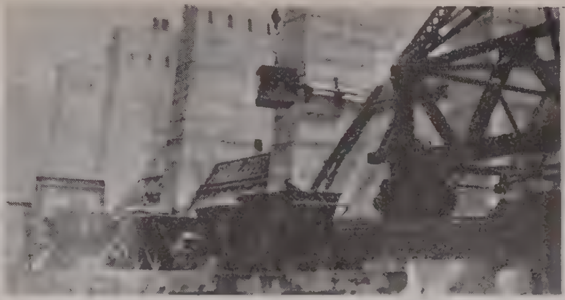
The Wilson Dam is correctly referred to as a monument to engineering skill and an example of the possibilities of concrete. Many ingenious solutions of intricate problems have been reached, and when the structure is completed, it will be the most up-to-date hydraulic power plant in the world. It is anticipated that it will represent the highest commercial efficiency and the lowest operating cost known to hydro-electric engineering at this time. The following information is released through the courtesy of Lieut. Col. George R. Spaulding, district engineer, Florence District, in charge of construction, and Hugh L. Cooper & Co., consulting engineers in charge of design and inspection, and J. W. Hall, resident engineer at Muscle Shoals; part of it being abstracted from a paper by R. P. Brown, construction engineer of the National Lime Association, and from observations of one of Concrete's staff. Concrete is indebted to The Lime Association for several of the accompanying illustrations.

The development of Muscle Shoals and the construction of the Wilson Dam across the Tennessee River were undertaken by the government early in 1918, in connection with the manufacture of nitrates for munitions in time of war and fertilizer in peace time. The project was assigned to the United States Engineer Corps, and construction was undertaken by the government, using hired forces working under civil service, after the design by Col. Hugh L. Cooper, then in active service. A special engineer district was created, and at present Lieut. Col. George Spaulding, U. S. Dist. Engineer, Florence District, has direct charge of all construction for the government. The Hugh L. Cooper & Co. organization now has charge of all design and inspection work in connection with the dam.

The length of the composite structure, or Wilson Dam, which is probably the largest concrete project in the world, is approximately 4500 ft. The power house section of the dam abutting the south shore is 1250 ft. long. The dam proper, or spillway section, extends from the north end of the power house to the lock, a distance of 3050 ft., and the lock section extends from the dam to the north shore, approximately 200 ft.

The power house unit referred to above is 1250 ft. long, 160 ft. wide, and 134 ft. high. It will house 18 turbo-generators. Four of these units will produce 30,000 h.p. each, and the other 14 units will each deliver 35,000 h.p., making available a total of 600,000 h.p. when the project is complete. This will be equivalent to approximately 700,000,000 kilowatt hours of primary power and 1,490,000,000 kilowatt hours of secondary power per year.

From the river bed to the crest of the dam or spillway is 95 ft. The total height from foundation to operating bridge is 120 ft. The base of the dam, which is of the gravity type, is 105 ft. wide.



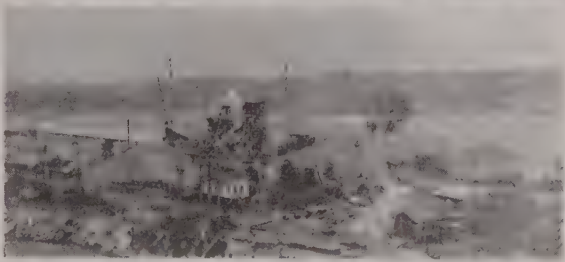


Fig. 2—Hoisting a 4-yd. Bucket of Concrete to the Spillway Forms

Fig. 3—The Largest Mixing Plant. This Plant is Located on Jackson's Island Near the Center of the Works

Fig. 4—Interior View at Jackson Island Mixing Plant. Each Batch Here Consists of About 100 Cu. Ft. of Gravel, 39.6 Cu. Ft. of Sand, 24 Sacks of Cement, and 2 Bags of Hydrated Lime

Courtesy U. S. E. D.

Concrete Required

The lock section at the north end of the dam will require, when completed, approximately 77,000 cu. yds. of concrete. The spillway section will require 703,285 cu. yds., and the power house section 511,500 cu. yds., or a total for the project of over 1,291,000 cu. yds. This mass of concrete may be more readily conceived when it is compared with an 18-ft. road, 6 in. thick, and 735 miles long, which could be built from the concrete involved.

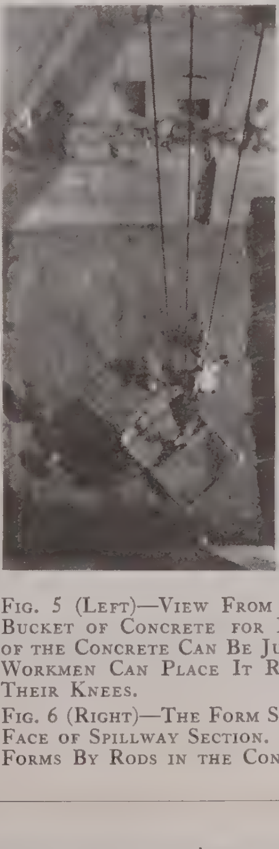
Three central mixing plants, served by 27 miles of narrow-gauge railroad, supply the concrete for the project. About 2500 men, working in three shifts, are employed. The largest mixing plant is near the center of the dam site on Jackson's Island. Two other plants are located on the shore of the river, one at each end of the dam. The Jackson's Island plant consists of two 4-yd. mixers, and each of the shore plants has two 2-yd. mixers. In order to handle these large amounts of concrete, bottom dump buckets of 2-yd. and 4-yd. capacity are filled at the mixers, transported on flat cars over the standard gauge railroad track, and picked up by cranes, by which the concrete is deposited into the forms at the particular section where concreting is being done. Three McMyler and 7 Perry full circle 10-ton cranes are used in placing concrete, setting up forms, etc. Twelve locomotive cranes, 26 standard gauge locomotives, 79 box cars, 65 flat cars, 15 gondolas, and sixty 20-yd. dump cars are used on the various parts of the project. These requirements in the line of equipment help to give an idea of the size of the job.

Concrete

Aggregates are obtained from the river bed, down river from the dam, and are transported, first by boat and then by rail, to stock piles at the mixing plants. The concrete is proportioned by volume with the aid of measuring hoppers filled from storage bins and discharging into the mixer charging hopper. At the Jackson's Island mixing plant, the largest of the three, the cement is supplied in bulk. At the two shore plants, the cement is handled in the original sacks. Piles of gravel aggregate at the Jackson Island mixing plant are shown in Fig. 3, which also shows the equipment for unloading the material and placing it in the storage bins.

Proportioning of Concrete

Proportions are based on the voids in the sand and gravel, the coarse aggregate being tested two or three times during each shift, or from six to nine times a day, to keep the mix constant. Each yard of concrete contains 25 cu. ft. of gravel or stone and 5 or 6 sacks of cement, the amount of cement depending upon where the concrete is to be used. This leaves only the sand subject to variation. The mortar, or cement and sand mixed, is required to be sufficient to fill



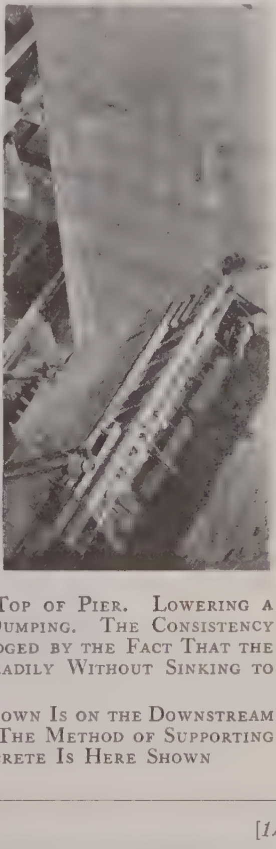


Fig. 5 (Left)—View From Top of Pier. Lowering a Bucket of Concrete for Dumping. The Consistency of the Concrete Can Be Judged by the Fact That the Workmen Can Place It Readily Without Sinking to Their Knees.

Fig. 6 (Right)—The Form Shown Is on the Downstream Face of Spillway Section. The Method of Supporting Forms By Rods in the Concrete Is Here Shown the gravel voids and provide an excess of 15%. Thus, for example, in a 5-sack batch of concrete, using the average void figures, the sand is computed as follows:

25 cu. ft. of gravel @ 40% voids,
i. e. 10 cu. ft. of voids
5 cu. ft. of portland cement
X cu. ft. of sand @ 34% voids.

This resolves into an equation wherein the total cement (5 cu. ft.) minus the cement going to fill the sand voids (.34X), plus the sand (X) equals the gravel voids (10) plus 15% (1.5). This reduces to

$$.66\ X = 6.5$$
$$X = 9.9$$

Therefore the cubic yard batch referred to will require 25 cu. ft. of gravel, 9.9 cu. ft. of sand, 5 sacks of portland cement, and one-half sack (25 lb.) of hydrated lime.

Using the void assumptions just noted, it will be seen that a 5-sack batch gives a nominal mix of approximately 1:3:5, while a 6-sack batch makes an approximate nominal mix of 1:1.4:4.2.

MIXING

The mixing at all plants is subject to 6 inspections, and in the 2-yd. mixers concrete is mixed for a minimum of 2 min. and in the 4-yd. mixers, the minimum time is 2½ min. If the sand or gravel happens to be running fine, the time of mixing is increased. A 2-yd. batch of concrete requires about 85 gal. of water, depending somewhat upon the condition of the sand and gravel. If too much water is used in a certain batch, that condition will cause the batch to be wasted at the point where it was intended to use it, and, on the other hand, if the batch is too dry, extra labor is required to place it properly.

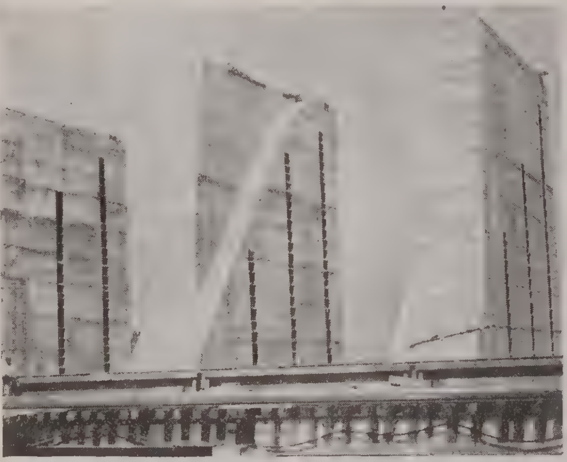


Fig. 7—One of the 12 Piers in the Spillway Section. The Smoothness and Uniformity of the Concrete Work Is Clearly Evident

Courtesy U. S. E. D.

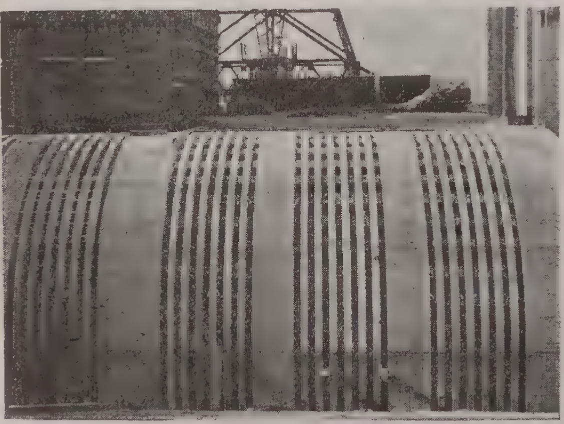


Fig. 8—Section of Grillage over Sluice Gates. This Section Is 230 Ft. Long and Protects 13 Sluice Gates, Each 9 Ft. in Diameter. Concrete Was Successfully Placed in This Section Under Particularly Difficult Form Conditions

Courtesy U. S. E. D.

CONSISTENCY OF CONCRETE

Figs. 5 and 6 give a good idea of the consistency of the concrete, which is strictly controlled in a rather novel manner. All laborers and inspectors connected with the placing of concrete in the forms are furnished with hip boots, and the consistency of the concrete must be such that a man working in it will sink not less than 2 in. nor more than 10 in. The fact that the concrete is placed to a depth of from 4 to 6 ft. in the forms before permitted to harden, will indicate that this requirement is rigid. If the men are walking around on the top of the concrete, it is evident that more water should be added to the mix, and in case the men sink in to their knees, the mix is too wet for the best results. Extreme care is exercised to prevent honeycombing, and a close check is kept on consistency and workmanship. Following tests, which were conducted on various materials, such as kaolin, talc, red clay, and hydrated lime, which could be conveniently and economically obtained to increase the workability of the concrete and prevent segregation in the buckets and during dumping, the use of 2% of hydrated lime by volume was first tried out, and later, in February, 1923, 5% by weight or 25 lb. per cu. yd. of concrete was decided upon. The addition of hydrated lime to the concrete in the above proportion has given satisfactory results.

All factors, including careful inspection, good workmanship in making the forms and in spading and placing the concrete, combined with a thoroughly mixed concrete not subject to excessive wetness nor segregation, have all combined to give surfaces to the concrete, the quality of which is indicated in the illustrations.

FORM WORK

Designing, building, and erecting the forms presented many unusual problems, due not only to the shape and size of the units, but also to the pressures which the forms must withstand. The pressure of the concrete on the forms is minimized by limiting the depth of the fresh concrete to from 4 ft. to a maximum of 6 ft. At least three days must intervene before fresh concrete may again be placed. Whenever possible, the forms are built at a central plant by specially trained workmen, and are there assembled so that they can be dismantled and taken to the job in units as required. Some of the curved and warped sections, used particularly in connection with the power house construction shown in Figs. 9 and 10, are excellent examples of form work. It is essential that the finished concrete surfaces be smooth, and that the curves

A Forest of Forms

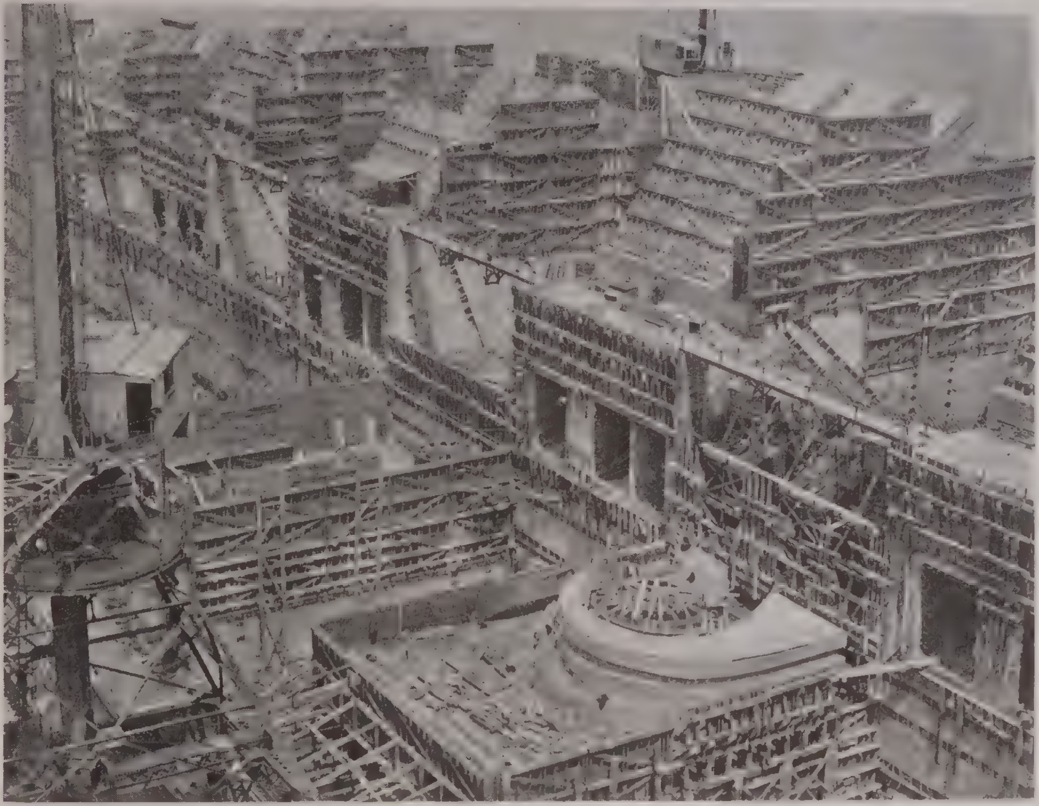


FIG. 9 — POWER HOUSE CONCRETE AND FORM-WORK. FORMS BEING ERECTED FOR PENSTOCKS. COMPLETED BASE FOR SCROLL CASE SHOWN IN FOREGROUND

Courtesy U. S. E. D.

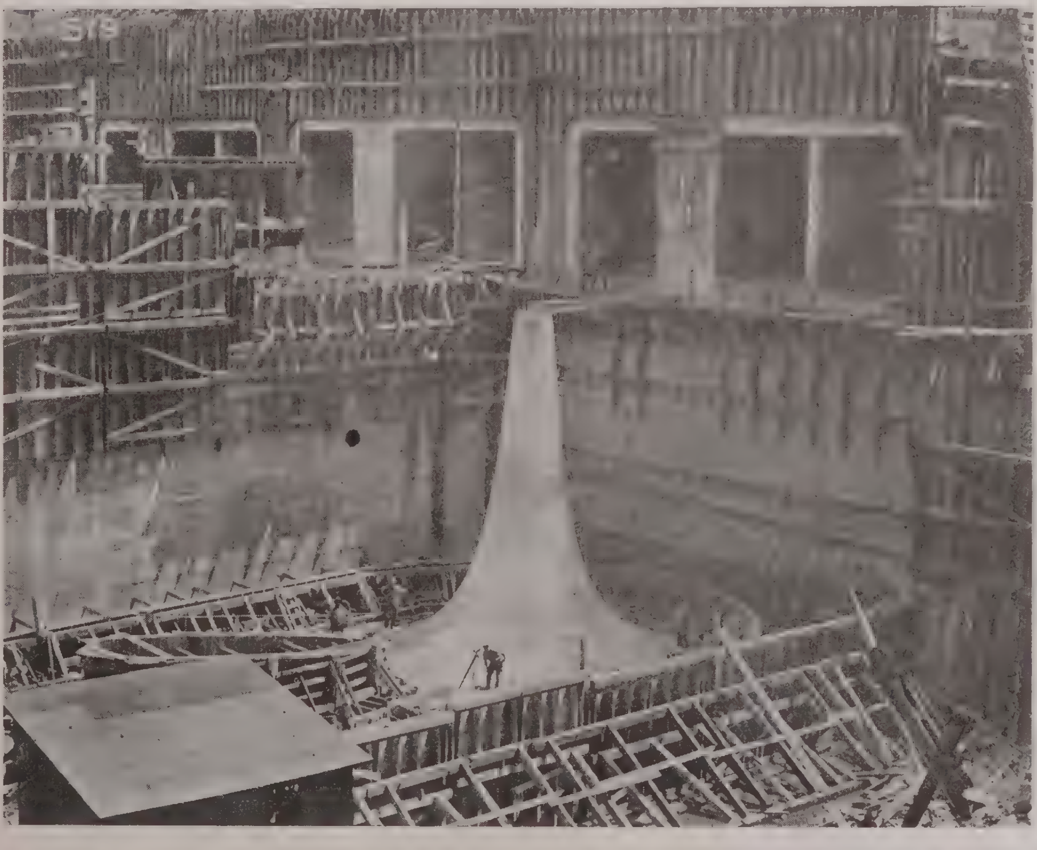
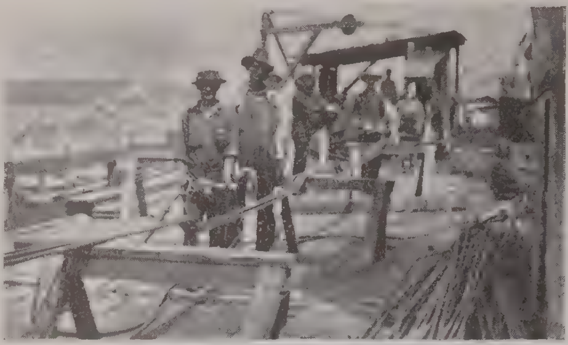


FIG. 10—DRAFT CONE FOR TURBINE. NOTE PARTICULARLY THE SIZE OF THIS CONE AND THE QUALITY OF THE CONCRETE WORK

Courtesy U. S. E. D.



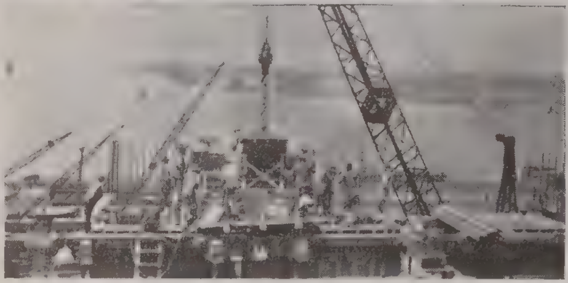


Fig. 11—Cleaning Rust from the Reinforcing Rods Before Placing Them in the Form

Fig. 12—Dumping a 2-Yd. Bucket of Concrete into a Hopper To Be Placed in the Forms For Power House Construction

conform exactly to the design, as otherwise a smooth flow of water to and away from the turbines would be impaired and difficulties hard to remedy would result. This requires carefully designed and well-built forms, in addition to good concrete for a smooth surface.

Reinforcing

Reinforcing rods are carefully cleaned of rust and scale with the aid of power-operated revolving wire brushes, as shown in one of the accompanying illustrations, before the rods are placed in the forms. This treatment of the steel produces a surface almost like new metal. Extreme care is exercised in placing and spacing the rods, in accordance with the plans. Where one section of concrete is to be joined later to another section, as in the arch ribs for the operating bridge, the ends of the rods next to the dividing form are threaded and filled with sleeves into which the reinforcing rods for the later section of concrete work are screwed, thus giving a continuous reinforcement bonding the two sections of concrete together.

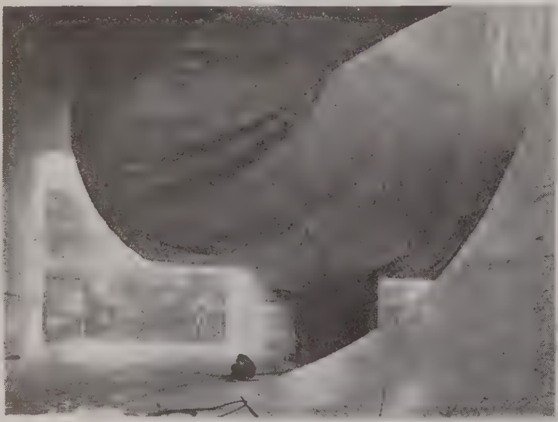


Fig. 13—Interior View of the Draft Tube Chamber. Note the Exceptional Character of the Surfaces and Consider the Difficulties of Placing Concrete Around Reinforcing in the Curved Forms Used

Courtesy U. S. E. D.

The forms for large masses of concrete, as in the spillway section shown in Fig. 6, are held in the proper place by rods embedded in the concrete approximately normal to the face of the forms.

Depositing Concrete

Where the space between forms permits, concrete is deposited directly through the bottom of the 2-yd. or 4-yd. dump buckets, and is placed by the workmen who stand in the newly deposited mix. In places where the buckets cannot be dumped directly into the forms, as in the top of the smaller units of the power house section, hoppers are provided, as shown in Fig. 12, into which the buckets are dumped and from which the concrete is shoveled into the forms and carefully spaded around the reinforcing.

Testing

Briquettes are made from mortar taken from the concrete being placed each day, the mortar being rubbed through a No. 8 sieve to eliminate all gravel. These briquettes are prepared, stored, and tested in the standard manner. In addition to the briquettes, a set of 15 cylinders is made about every 5 days from fresh concrete while it is being placed. These cylinders are tested in series of 3 at the ages of 14 days, 28 days, 3 months, 6 months, and 1 year. In making the cylinders, the molds are filled in three layers, tamping with a bar only enough to insure uniformity. The cylinders remain undisturbed for two days, then are taken to the job laboratory, where they are carefully numbered and packed in sawdust and shipped to the concrete laboratory of the U. S. Bureau of Standards at Washington, D. C., for breaking. At the same time that the cylinders are made, 75 briquettes are prepared, which are stored and tested at the laboratory of Hugh L. Cooper & Co. on the job, under the supervision of J. C. Evans, test engineer, to be broken in sets of 5 at the following ages: 7, 14, and 28 days; 3, 6, and 12 months; 2, 3, 4, 5, 6, 7, 8, 9, and 10 years. Laboratory tests are made of every carload of cement and lime used, and a series of check tests is carried out on the sand and gravel. Sufficient storage space is available on the job to insure that untested material will not be used, and all material used is required to meet rigid specifications.

After all is said, a big job of concrete is merely a thousand little jobs rolled into one—each factor of material, mix, men and equipment multiplied by other factors of area and bulk. There is this other consideration—a large job concentrates responsibility—if something goes wrong on a big job the error mounts up into huge liability.

Davis Monument—Country's Second Highest

How It Was Built of Concrete

The Davis Memorial monument erected at Fairview, Ky., and dedicated June 7, last, to the memory of Jefferson Davis, is a shaft of concrete 351 ft. high and second in size to the Washington monument. Even under ordinary conditions, the building of such a structure requires considerable engineering skill and as part of this work was done under war time conditions, with the necessity of using what materials and means of construction were available, the job has several points of unusual interest. The construction work, begun in 1917, was interrupted in 1918 because of the World War and was resumed in 1922.

The structure is 35 ft. sq. at the base with a foundation 40 ft. square and 18 ft. deep resting on solid rock. As will be seen from the illustration, there is a slight uniform taper from the bottom to near the top where the angle changes giving the top pyramidal section which has a cap of copper 12 in. high and 18 in. square. The surface is of a mixture of white cement and pulverized limestone.

CONSTRUCTION METHODS

Rock for the coarse aggregate was quarried about 900 ft. from the site of the monument. At the beginning of operations in 1917, rock was crushed at the quarry and transported to the base of the monument by means of slat bed wagons. After struggling along with the work during the war period, with little or no labor available except convicts, G. R. Gregg, the general contractor changed his method of operation. The crusher was removed to the monument site and bins high enough to allow the crushed material to be delivered to them were erected. From the screen all under-size and over-size rock passed back to a Day pulverizer[1] and was reduced to ¼ in. and under. This product was again elevated to a bin from whence it was drawn for use as fine aggregate in place of sand.

The site of the monument is 7 miles from the nearest railroad, the nearest and best shipping point being Pembroke. The freight charges and long haul made river sand out of the question, necessitating the use of the crushed limestone which not only met the specifications for the monument but also the government specifications for the kind of work involved.

After the crushing equipment was moved to the base of the monument, an inclined railroad was used with 2-yd. side dump cars to bring the rock from the quarries to the crusher. A hoist for handling the cars was placed about 600 ft. from the monument directly under the track, which at that point had what is known in railroad yards as a gravity hump. There was a fall of only 1 ft. in 100 ft. from the hoist to the monument and a rise of 10 ft. per 100 ft. from the quarry to the hoist. A hoist and cable attached to the front axle of the car by a special fastener that allowed the axle to revolve within it, served to pull the loaded cars from the quarry to the hump. From there the cars coasted down to the crusher at the monument dragging the cable with them. A semaphore signal was used similar to that used on the railroads and when a car was emptied and the proper signal given, the car was pulled back to the hump by the same hoist and allowed to coast down into the quarry.

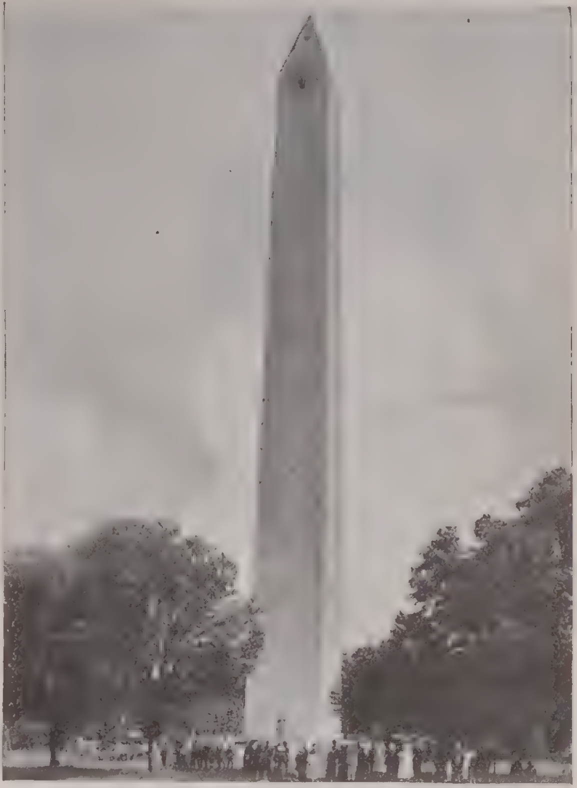


FIG. 1—THE JEFFERSON DAVIS MONUMENT AS DEDICATED JUNE 7, 1924

A 12 h. p. power Frick steam traction engine[2] was used to run the hoist and also supplied steam to the quarry for running an Ingersoll-Rand tripod drill.[3] The quarry was a good one, absolutely void of any dirt seams or foreign matter of any kind, producing a desirable concrete aggregate.

A J. I. Case 10-in. x 20-in. jaw crusher[4] was used in crushing the stone. It was driven by a 35 h. p. Nichols Sheppard steam traction engine[5] which also furnished steam to operate the elevator engine. All water used by the engines, and mixing water for the concrete was pumped from an 80-ft. driven well by means of a 3 in. Red Jacket pump[6] operated by a 5 h. p. Hercules gasoline engine[7] which also drove the dynamo to furnish light inside the monument.

Kosmos portland cement was used exclusively for the concrete and Atlas White and Medusa cement mixed in the proportion of 1 cement to

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[1] Day Pulverizer Co., Knoxville, Tenn.

[2] Frick Co., Waynesboro, Pa.

[3] Ingersoll-Rand Co., New York City.

[4] J. I. Case Machine Co., Racine, Wis.

[5] Nichols & Sheppard Co., Battle Creek, Mich.

[6] Red Jacket Mfg. Co., Davenport, Ia.

[7] Mason, Marcus & Co. Inc., Boston, Mass.

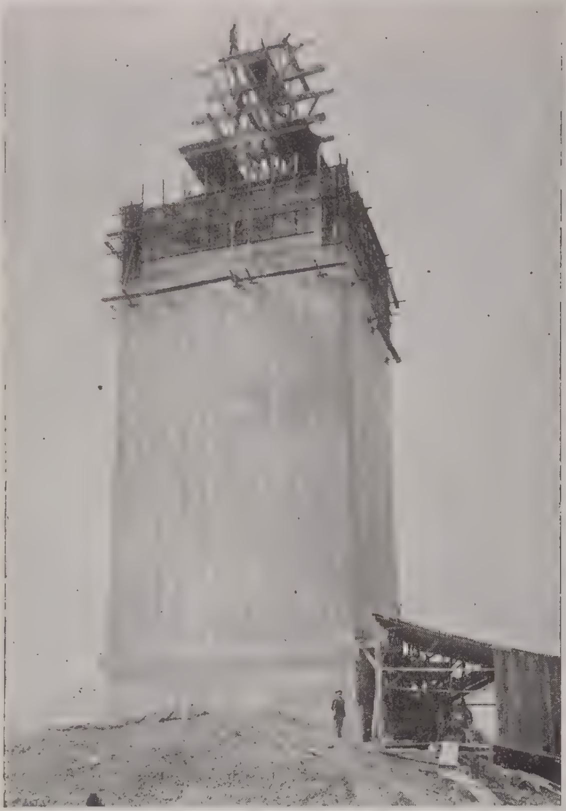


Fig. 2—The Monument During an Early Stage of Construction

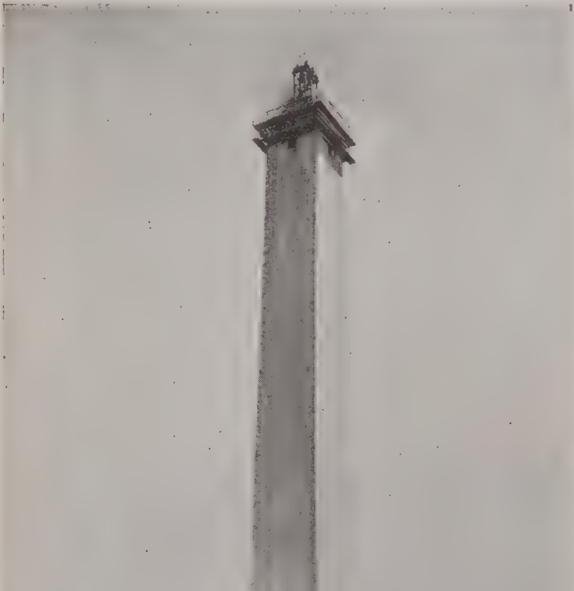
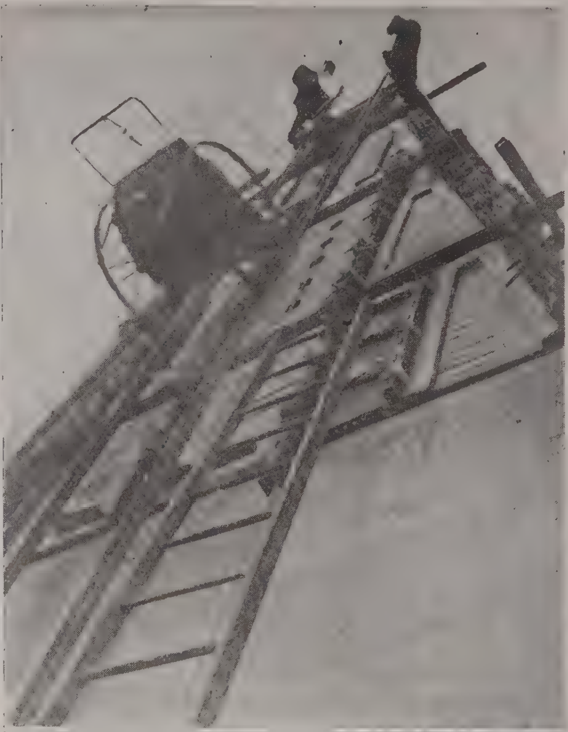


Fig. 3—View Showing Progress Made up to May 30, 1924 with the Flag at the Elevation of the Top of the Finished Shaft



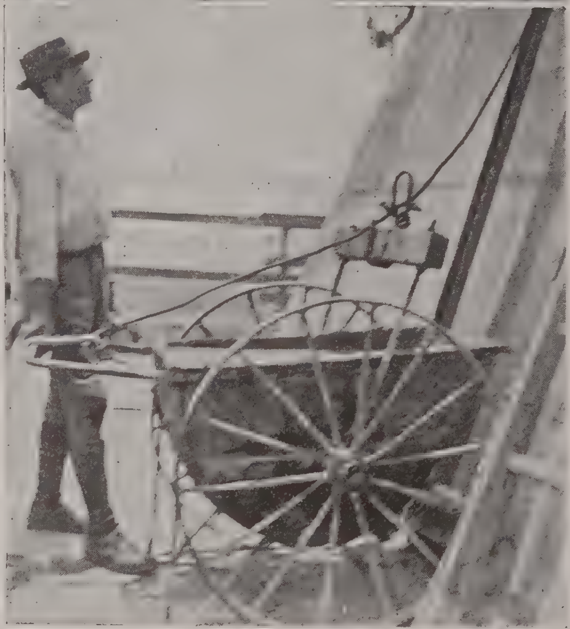


Fig. 4—View Looking Upward Showing the Buggy on the Way up. The Buggy Wheels Follow the Channel Iron Track

Fig. 5—Concrete Buggy Ready to Start on Its Way to the Top from a Platform 318 ft. up

2 of fine aggregate were used for the facing. Concrete was of 1:4 mix. Cement was hauled 7 miles from Pembroke by truck. The first lumber used in the construction work was country sawed and delivered to the contractor by four oxen. The oxen and the motor trucks might be considered as representing the two extremes in modes of transporation of construction materials.

When in 1918 the government placed an embargo on lumber required for the work and local mills could not get any help, the contractor had to cut logs in the woods, haul them to the site of the monument and saw them into lumber as required. A saw mill was fitted out at the base of the monument.

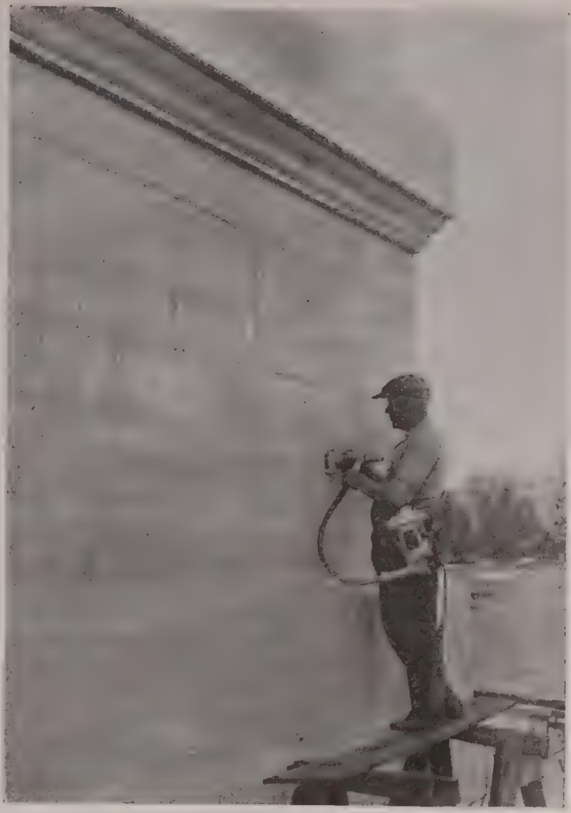


Fig. 6—Finishing Surface of Concrete with Surfacing Machine, Davis Monument

Forms

The hydraulic steel forms used had a diminishing corner panel every 4 ft., the corner post being battered $\frac{3}{16}$ in. per ft. of vertical height and the sides of the posts being plumb. A double cage elevator served throughout the entire construction and although the scaffolding was all attached to the 6-post elevator tower and had to be taken out and moved up for every 8 ft. of height, it worked very satifsactorily until a height of 176 ft. was reached Near the top the scaffolding was changed to the suspended type supported by 4 steel cables operated on drums by men on the scaffold. The lower inside scaffold and the four outside scaffolds were carried in this manner and the method was entirely successful from the time of its adoption to the completion of concreting operations.

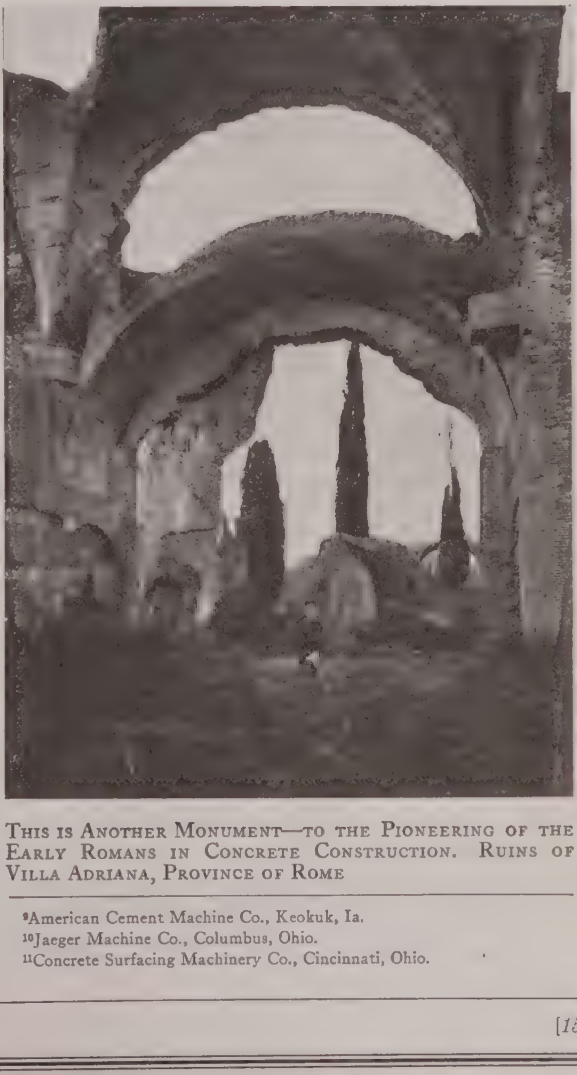
The elevators were run by a double cylinder Byers steam engine[8] with an especially constructed set of drums and brakes which made it safe. Only one man was slightly injured during the construction work due to an oversight on the part of the elevator operator. The elevators were operated from the ground level according to signals given by electric bells.

Fig. 3 shows the monument nearing completion on May 30, 1924, with the flag floating from the elevation of the top of the finished shaft. The lower outside scaffold had an adjustment of 7 ft. which was sufficient to permit removing the lower forms and again placing them above. The upper scaffold was used throughout the entire construction of the top only. Concrete was poured from the elevator tower to 14 ft. above the scaffold where the forms came in contact with the tower. After that, the concrete was elevated to the scaffold shown at a height of 318 ft. and from there it was hoisted by cable running through the top and over a block. The loaded elevator inside backing down, pulled the buggy filled with concrete up the outside, the wheels of the buggy running in guides up the outside of the structure. Fig. 5 shows a buggy filled with concrete on the platform 318 ft. from the ground and ready to start up. Fig. 4 shows the buggy on the way up with the men ready to receive the concrete.

Boss mixers[9] were used exclusively on the job except for a short time in finishing the concreting in 1924 when both Boss and a Jaeger 4-L mixer[10] were used, the latter having been transferred by the contractor from a bridge job and pressed into service on the monument in order to have the work completed by June 7.

Streaks caused by water and cement running down the outside of the structure during construction were left until all the work was done because of the taper of the sides of the monument. The cleaning of the surface was done successfully with two Berg concrete surfacing machines.[1]

Since the dedication of the monument, the contractor has built a replica of the Jefferson Davis home, of log and frame construction. While the house appears old fashioned in a way, it is modern in that it is heated by a pipeless furnace and has water works and electric lights.



This is Another Monument—to the Pioneering of the Early Romans in Concrete Construction. Ruins of Villa Adriana, Province of Rome

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[8] John F. Byers Machine Co., Ravenna, Ohio

[9] American Cement Machine Co., Keokuk, Ia.

[10] Jaeger Machine Co., Columbus, Ohio.

[11] Concrete Surfacing Machinery Co., Cincinnati, Ohio.

Storing and Handling of Materials for Concrete Products

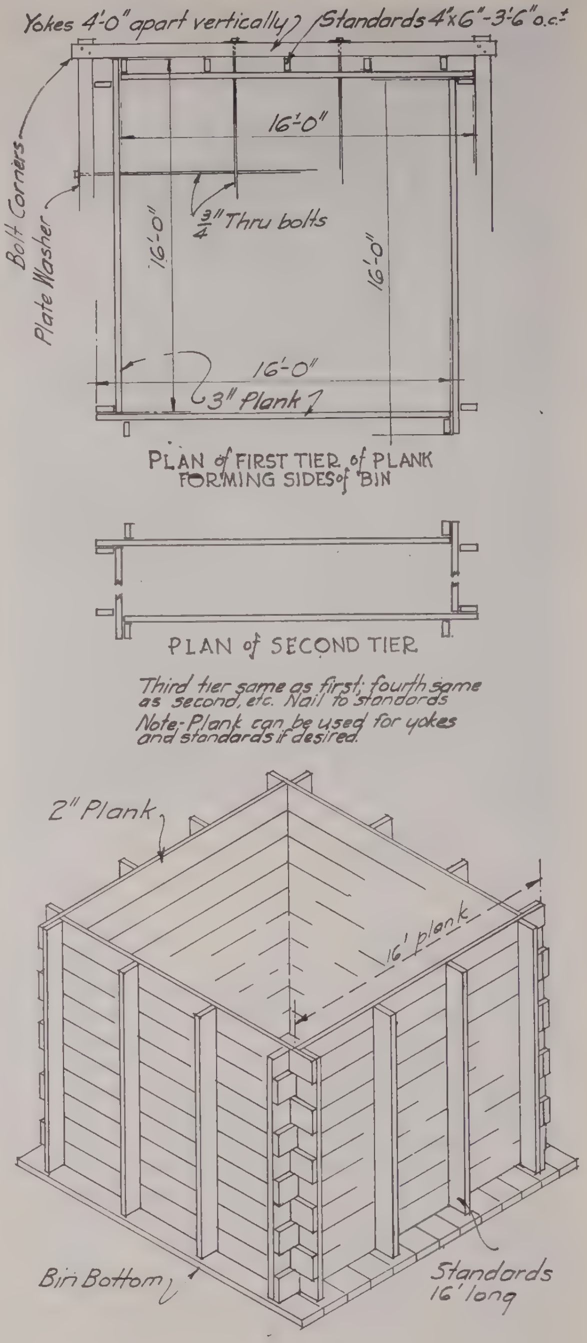
By William F. Lockhardt

Methods of excavating aggregates for concrete products manufacture were discussed in a previous article.[1] This dealt principally with the methods available for excavating purposes, and their capacities, with some mention of conveying equipment. The items of reserve storage, reclaiming from storage, and delivery to the plant, were not touched upon.

The idea of reserve storage—the intermediate step between the production of the raw material and its conversion into a finished product— is of course to guard against interruptions to plant operation by reason of lack of raw materials. The interest on money invested in mechanical equipment goes on whether the plant is operating or idle and many other items of overhead also continue to pile up. In addition, a forced shutdown during a normal working day means the loss of part or all of the time for the operating force for that day, unless there is other work available to which they can be shifted and at which they can really be profitably employed.

The principal interruption to be considered is of course that occasioned by winter weather conditions, when it may be impractical to attempt to work the bank or pit from which the aggregates are obtained. The broad question of winter operation of concrete products plants, while highly important, has of itself no place in this article, other than as it affects the layout and equipment of the plant. The probable operating policy with regard to the winter season should be decided, as far as possible, while the plant layout is still on paper, as there is nothing to be gained by spending additional money to ensure an adequate supply of raw materials for continuous year-round operation if there is not a sufficient volume of winter construction to absorb the plant output, or if the plant is not able to arrange for the financing of winter operation for the purpose of building up adequate reserve stocks of finished products in anticipation of the spring demands.

It naturally goes without saying that any reserve storage intended to carry the plant over the winter months must be large enough to furnish a normal supply of aggregates to each machine that it is intended to operate, for such a period as may be fixed by local climatic conditions as being unsuitable for bank or pit operation. In general in most localities this can be taken as about four months, from November 15 to March 15, slightly less than 100 working days, although there are many places where the season can be shortened to about 70 days, say from December 1 to March 1.


Yokes 4'-0" apart vertically
Standards 4"x6"-3'-6" o.c.±
16'-0"
Bolt Corners
Plate Washer
3/4" Thru bolts
16'-0"
16'-0"
16'-0"
3" Plank
PLAN of FIRST TIER of PLANK FORMING SIDES of BIN
PLAN of SECOND TIER
Third tier same as first; fourth same as second, etc. Nail to standards
Note-Plank can be used for yokes and standards if desired.
2" Plank
16' plank
Bin Bottom
Standards 16' long

Yokes, tie-rods, and supports for bin omitted

Fig. 1—Small Aggregate Bin for Storage of Materials at a Near Mixer

Fig. 1—Construction of Simple Bin. Sills, Posts and Girders Underneath Bin to Be Same as for Bin in Fig. 2

The amount of sand required for these two periods for block, brick and tile plants of various capacities are given below:

Output per day	Aggregate in cu. yds. required for 1 day	70 days	100 days
BLOCK 8 x 8 x 16 (assumed at 66 block per cu. yd.)			
200	3.03	212	303
800	12.12	848	1212
1800	27.27	1909	2727
3000	45.45	3181	4545
TILE—5 x 8 x 12 (assumed at 160 tile per cu. yd.)			
3000	18.75	1312	1875
4000	25.	1750	2500
5000	31.25	2187	3125
BRICK (assumed at 1.6 cu. yds. per thousand brick)			
8000	12.8	896	1280
24000	38.4	2688	3840
48000	76.8	5376	7680

From these figures can be gained some idea of the quantities of aggregate needed to operate a products plant at capacity over the winter season.

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[1] Concrete July, 1924—"Economical Handling of Raw Materials in Building Unit Manufacture."

Beside the reserve storage mentioned for winter operation a smaller reserve at the mixer is also desirable to guard against minor interruptions to the supply. This mixer reserve is usually in the form of a bin or silo, and may have a capacity equal to anything from a few hours run of the plant to a supply sufficient to maintain production for several days.

Fig. 1 shows the plan of a very simple wooden bin often used on building construction jobs. It is intended to be built throughout of 16 ft. stock lumber with a minimum of cutting, and as shown will hold about 130 cu. yds. of material. This bin should be elevated sufficiently so that the aggregate can be drawn from it at several points in the bottom, otherwise there will be large pockets of material in the corners that will not flow out when the gates are opened, and which will have to be shoveled through the gates, or into a pile over the gates, involving in either case additional labor charges. A larger bin, used on a construction job where it was desired to have a bin large enough to hold several different aggregates, is shown in Fig. 2. This bin has a capacity as built of about 165 cu. yds., and is particularly suited for plants where several sizes or kinds of aggregates are carried.

The bin shown in Fig. 1 can be modified to cut down the cost by omitting the platform on which it has been suggested that it be built. The bin can be built resting directly on the ground, the vertical dimension being increased to 20 or 22 ft. Assuming that the bin gates will be placed 6 or 7 feet above ground the bin will then have a capacity above the level of the gates about the same as the bin in Fig. 1. The bin gates should preferably be placed on several sides, and at least two to a side, if possible, in order to bring as much material within reach of gates through which it will flow without shoveling. The material below the level of the gates should also be aggregate, which can then be considered as a final emergency reserve which can be obtained if absolutely needed to avoid a shutdown by putting one or two laborers into the bin to shovel through the gates.

The last named type of wood bin is similar to a silo. Silo design and construction for sand storage and coal storage is well standardized. Monolithic concrete, concrete silo blocks, or concrete silo staves may be used. Silos are always circular in plan, and are reinforced with steel rods or hoops to withstand the bursting pressure of the material inside. As silos are generally built to rest on the ground, the material is withdrawn through gates in the sides; it should therefore be borne in mind in figuring the storage volume that all material below the level of the gate is "dead" storage, which must be subtracted from the total capacity of the silo to determine the amount of "live" storage. It must also be remembered that sand will not flow below a certain slope, so that if only one gate is used there will be additional dead storage between the level of the gate and this slope-line, or "angle of repose", as the engineer calls it.

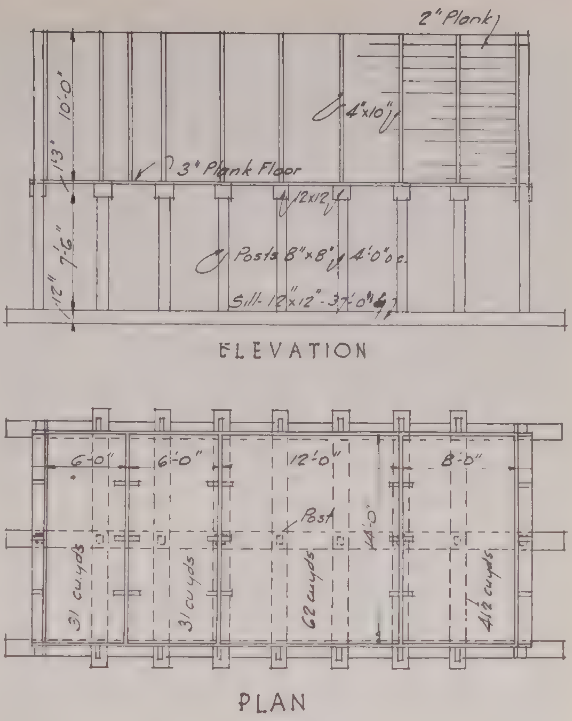


Fig. 3—MultiCompartment Bin for Storage of Several Kinds or Sizes of Aggregate

Table of Capacities of Circular Silos in Cubic Yards

Diameter of Silo Height of Silo	10 ft.	12 ft.	14 ft.	16 ft.
16 ft.	46	67	91	119
18	52	75	102	134
20	58	84	113	149
22	64	92	125	164
24	70	101	136	179
26	75	109	147	194
28	81	117	158	209
30	87	125	170	224
32	92	134	181	239
34	98	142	193	254
36	104	151	204	268
38	110	159	215	283
40	116	167	226	298

In addition to the above, steel bins, both circular and square in plan, and of various sizes, can also be obtained. These are usually designed to be supported by steel legs which are furnished by the manufacturer to enable the sand or other material to be drawn from the bottom. Sloping steel bottoms are usually furnished under these circumstances.

Storage Piles and Their Location

The methods just enumerated are suitable only when a moderate amount of storage is required. When the storage required gets up into the hundreds and thousands of cubic yards, there is only one possible method which can be employed at a reasonable cost—that of building up one or more storage piles on the open ground. The capacity of such a storage pile may be materially increased by the use of timber bulkheads 4 to 6 ft. high, at moderately increased cost, as low walls of this kind can be easily braced, but for greater heights a reinforced concrete retaining wall would be the most practical, involving a greater investment than most products plants care to make.

In planning to build up a storage pile each year as a regular feature of plant operation effort should be made to so locate it that it can be easily reached from the bank or pit and from the plant. It should, if possible, be in what is known as the "line of flow" of the aggregate from the bank to the plant, or in other words, along the general route followed by the aggregate between the two points mentioned. This does not mean that the pile should literally be in the way, so that it blocks the shortest line between the two points, but it is better practice to locate the storage pile somewhere along the path followed by the aggregate, where this can be done, than to put it off in some corner where needless expense is going to be involved by the use of man power and additional equipment to get the aggregates to and from it. As all the material which goes into a storage pile will presumably be taken out of it again, and under unfavorable working conditions in many instances, it follows that the pile should be so situated that easy access can be had to it from at least one direction by the digging and conveying machinery to be used, if rehandling costs are to be kept down.

Building Up Storage Pile

Various methods can be employed to build up a storage pile. There are many methods in use in large industrial plants for storage and reclaiming coal, ore, etc., that are too elaborate for the average concrete products plant, so this discussion will be confined to the simpler and less expensive methods.

In many cases the methods employed for excavating can be adopted. Either horse or tractor-drawn slips or wheeled scrapers can of course be used. A locomotive crane with clamshell bucket will build up a very substantial storage, working from both sides of a given area.

Sometimes the conveying equipment in use between the bank and the plant can be used or adapted to this work. The ordinary belt conveyor with its extremely simple supporting framework can be used or adapted. Where the available belt conveyor is too short to be effective as ordinarily operated, its range can be greatly increased by running it at a considerably greater speed, so that the aggregate, instead of simply pouring from the discharge end, will be violently thrown off. If the discharge end of the conveyor is tilted up at an angle with the horizontal the aggregate can be thrown from 20 to 40 ft. by this expedient.

Or, where the belt conveyor runs for some distance at any considerable elevation above ground, a continuous storage pile can be built up immediately under the conveyor by setting an 8 ft. or 10 ft. board diagonally across the belt between idlers to act as a plow to throw the material off the belt. The location of the plow can be changed as often as may be necessary. This method of unloading, while not recommended by the manufacturers of belts, does not involve the expense of buying and installing a movable tripper with its tracks, etc., works satisfactorily, and if not prolonged into indefinite use, does not seem to work serious damage to a good belt.

The motor truck, if available, can of course be used to good advantage. A start should be made at one end of the storage area, dumping three or four loads abreast, in two or three rows. These piles can then be trimmed down to an easy slope, and the top planked with second hand lumber. The trucks can then back up the inclined runway thus formed and dump from the high end, which is trimmed up and planked over as fast as may be necessary to keep pace with the trucks. The two advantages of this method are its speed and simplicity. With 5-ton back-dump trucks available, from 500 to 1000 cu. yds. can be piled per day in storage, working from one end of the pile, the yardage being limited only by the speed with which the trucks can be backed up the slope and dumped. The equipment, aside from the trucks, consists only of the second hand planking which can be used over and over again.

In bins, and silos particularly, provision should be made for heating the aggregate during cold weather to prevent freezing, not alone because of the possible shutdown that would be occasioned thereby, but because whenever sand which has been frozen is used immediately after thawing out, there is considerable danger of including in the mix small lumps which have not been fully thawed out, resulting in sand pockets in the finished product. Also, snow or ice, if they are in the sand, will go through the mixer and products machine and into the curing rooms before melting; whole carloads of block in one plant last spring slumped down, ran together, and finally set up in a solid mass covering each tray of the block cars simply because of a sudden snow squall that came up while several loads of sand which had been dumped in the receiving yard were being shoveled into the charging skip of the mixer. The snow in the already cold sand went into the curing rooms before thawing, resulting in the loss of a number of carloads of block.

Steam for heating and thawing is the most practicable as a general proposition. Dry heat from steam pipes alone is not as effective as live steam. The usual method of employing steam is to place a pipe coil or grid covering the bottom of the bin or silo. The pipes forming the coil are perforated to permit the escape of the live steam. The perforations in the pipes should naturally be downward to reduce the likelihood of their being clogged by sand; still better results are obtained by substituting slots cut across the pipe with an ordinary hacksaw.

Where small quantities only of sand are to be thawed at one time the job can be done by piling the sand on a large sheet of old boiler-plate supported on a few block and building a hot fire under it. Another method much used by contractors is piling the sand over a piece of culvert pipe and building a fire inside the pipe. If the pipe is set on a slight slope it will be found to draw satisfactorily. The use of hot water for the mix will of course further reduce the chances of any unthawed material getting past the mixer.

Where it is necessary to work a large outdoors storage pile in the winter it is naturally impractical to undertake a steam coil installation under the whole pile. The general practice in thawing frozen material piled in this manner is to use several perforated pipes, each 5 or 6 ft. long, attached to a steam line by a length of rubber steam hose. These pipes are worked or driven into the end of the storage pile, which is usually the working face and after the steam has been turned on the end of the pile is covered with old tarpaulins, which are carried back on the sides of the pile a short distance to confine the steam and start the sides thawing.

(To be continued in Concrete for November, 1924)

How Portland Cement Is Made

By Dwight F. Jennings
Associate Editor CONCRETE

To all habitual users of concrete, who are the regular readers of this magazine, it is scarcely necessary to say that concrete is—"a compound of gravel, broken rock, or other aggregate bound together by cement." If we are to believe the dictionary, it makes very little difference what that cement or binder is. Fortunately, the dictionary makers *observe* usage and do not make it. The definitions begin with the usage and not the usage with the definitions. So, we know, that concrete is, to common understanding, unless otherwise specifically qualified, a product made possible by hydraulic cement, and we know that because portland cement has been in the ascendant for the last hundred years as a hydraulic binder, it is portland cement concrete that is meant when concrete is mentioned.

The name "portland cement" was almost accidental. Aspdin's early product bore a color resemblance to Portland stone. There is nothing more in the name than that.

Abundant Raw Materials

Natural deposits of minerals used in the manufacture of portland cement are abundant throughout the world. The principal natural elements of portland cement are lime, silica, and alumina. Various combinations of these raw materials are mixed, artificially, in the process of manufacture, yet all the combinations are made in keeping with definite chemical laws which govern the standard result. Since it was discovered that certain siliceous clays containing alumina and some form of lime or limestone were desirable chemical elements for hydraulic binders, the progress in manufacture has been marked. The present portland cement industry represents one of the major industries of the world, an investment in the United States alone of more than $300,000,000, and combinations of cement, rock, and limestone, blast furnace slag and limestone, clay or shale and limestone, or clay and marl are the most common ingredients.

The raw materials, of which 2½ tons are necessary for a ton of finished product, are absurdly common for such refinements as are necessary for the finished result.

The chemical properties of portland cement have become so definitely established that the industry may be classed as a chemical industry. Manufacture combines the proper proportions of calcareous and argillaceous materials. Calcareous materials include limestone, marl, oyster shells, chalk, and alkali waste. Under argillaceous materials are classed: clay, slate, shale, blast furnace slag, and cement rock. The natural cement rock may, however, be either argillaceous or calcareous, depending upon the proportion of the predominating material, silica or lime.

The manufacturing process consists first in combining large quantities of the raw materials in the right chemical proportion and grinding them to extreme fineness, then burning the mixture at a white heat to form clinker, and, in turn, grinding the clinker with the addition of a small percentage of gypsum, all to an impalpable powder. The definite control of the raw mix and the extreme high temperature of burning are distinguishing factors in the manufacture of portland cement.

What the Raw Materials Are

Although limestone is one of the commonest rocks in the earth's crust, the deposits being widely distributed, many of the deposits are not of the proper composition. The term limestone is a general one, referring to that class of rock containing 80% or more of carbonates of calcium and magnesium.

Marl is a more or less pure carbonate of lime, the principal impurities being clay or organic matter and carbonate of magnesia. Marl beds are ancient, extinct lake beds or deposits at the bottoms and banks of existing lakes. Marl deposits are confined almost exclusively to Ohio, Indiana, and Michigan. The material has been formed (and in some places the process is still going on) by the precipitation of calcium carbonate from water by the agency of certain algae or water plant.

Clay is a mixture of kaolin, a hydrated silicate of alumina, containing more or less sand and other impurities. Silica occurs in the clay, both as chemically combined silicate and in the free state as quartz sand. Pure clay, which is seldom found in nature, is formed by the dissolution of feldspatic rock. The clay should contain, roughly, about two and one-half times as much silica as alumina.

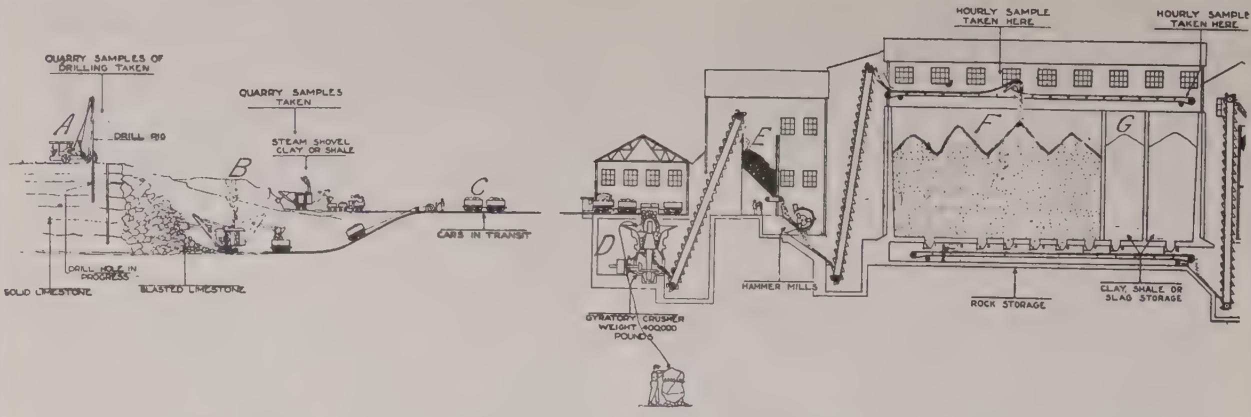
Shale has practically the same composition as clay, the main difference being that shale has been pressed into layers and condensed so as to resemble stratified rock. The extreme pressure, due to the disturbances in the earth's crust or to the weight of the material deposited on top of the shale, makes it resemble more closely rock formation.

Combinations of shale with limestone in the manufacture of cement have proved very satisfactory, since there is less tendency for the two materials to become segregated in handling after they have been ground and mixed. Combinations of clay and marl have likewise been found satisfactory, and also combinations of clay and chalk.

Blast furnace slag is used in the manufacture of two kinds of cement, one a true portland cement, in which the raw materials are blast furnace slag and limestone burned in the regular process. Slag cement is made by grinding slaked lime with suitable slag that has previously been chilled by dropping the hot slag into water. This is ready for use after grinding without further burning.

The gypsum, which is added in the percentage of not more than 3% of the clinker before finished grinding, is a hydrated sulfate of lime. The purpose of gypsum is to regulate the setting time of the resulting cement.

The preparation of the raw material has been fairly well standardized for both the wet and dry processes of manufacturing. In the dry process,



THIS DIAGRAM SHOWS THE "FLOW SHEET" FOR A TYPICAL PORTLAND CEMENT PLANT. FOLLOW EACH STEP IN THE MANUFACTURING PROCESS BEGINNING AT *A* ABOVE AND ACROSS THE TOP OF PAGE 159; THEN DOWN TO *M* AT THE BOTTOM OF PAGE 158 AND ON TO *V* ON PAGE 159

the moisture in the material is dried out before the fine grinding, while with the wet process more water is added during the grinding, so that, instead of being ground into a fine powder as in the dry process, the materials are reduced to a slurry of about the consistency of cream and containing about 32% water. After the raw material is fed to the kiln, the manufacturing process is the same, whether the materials are wet or dry.

QUARRYING OR DIGGING THE MATERIALS

The first step in obtaining the raw materials depends entirely upon their character. The raw materials may be quarried, mined, or excavated for delivery to the crusher. When rock is used, as is most common in American cement plants, it is necessary in some places to remove the earth or over-burden from the top of the rock strata. This material, however, is often of such composition that it can be combined with the rock as a raw material, and consequently no stripping is required.

Quarrying methods vary. Where the rock is hard, drilling and blasting are required. In other localities, materials, such as chalk and shale, may be excavated by steam shovels or special mechanical equipment. More than 15,000,000 lb. of dynamite are used annually in the cement industry in the United States.

Varied impressions are obtained by visiting different quarries or mines. The geological formation is carefully studied before the quarry is first opened up. If the rock formation which is to be used as raw material occurs on the side of a hill, the rock is removed and a quarry face established, the depth of which increases as the operations of drilling, blasting, and excavating with steam shovels gradually eat into the side of the hill. Where the surface of the rock strata is comparatively flat or level, the quarry is opened up in pit fashion, and after the material has been removed to the first level throughout the entire area, a new level is established giving a new floor at a greater depth.

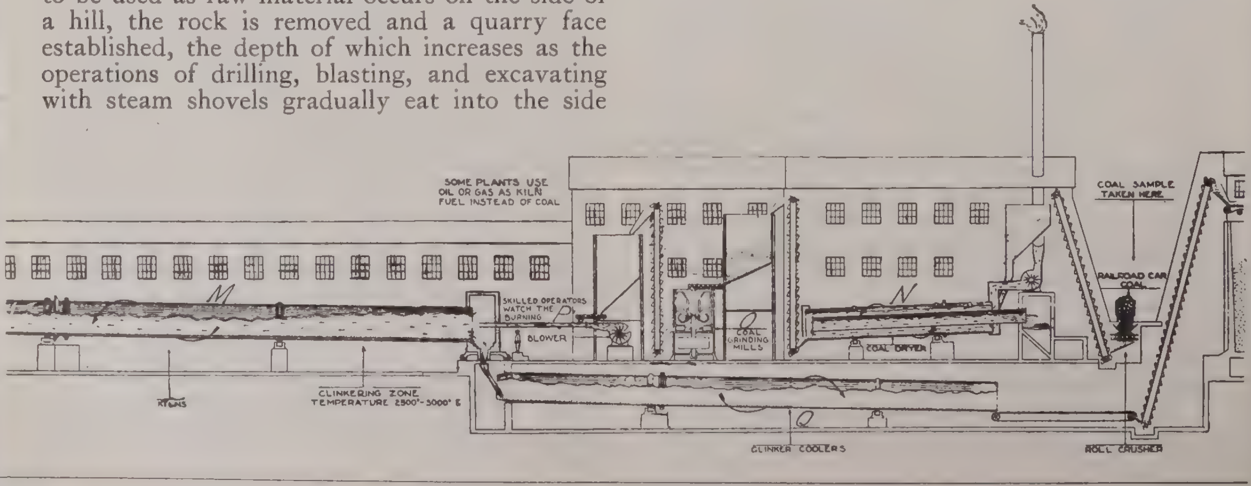
The drilling of blast holes is shown at *A* in the accompanying diagram. Rows of holes are drilled back of the quarry face, and when more rock is required, the holes are loaded with explosives and all of the charges connected by insulated wires, so that at the proper moment the pressing of a button on the detonator sets off the explosives, causing a mass of broken rock to slide down the quarry face to the floor. During drilling operations, samples of the rock are taken for chemical analysis. Where the chemical composition of the rock varies in different parts of the quarry, approximately the proper mixture can be obtained by loading part of the raw material from one side of the quarry and part from another.

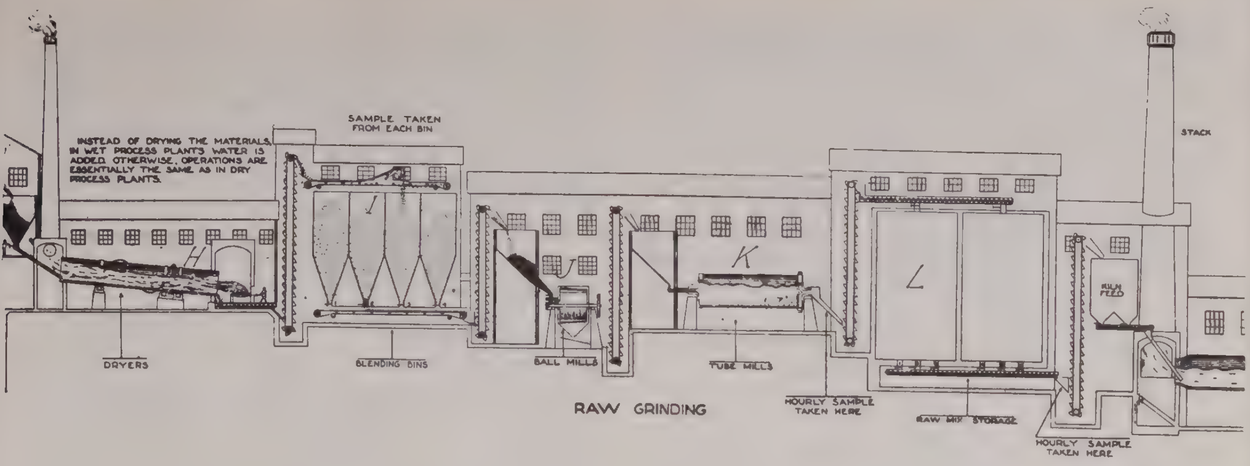
While the limestone rock is being loaded onto cars, the other raw material, clay or shale, is being excavated in the clay pit or shale quarry, *B* in the illustration, for transportation to the raw department. Quarry samples are also taken of the clay or shale, and are used in determining the proper mixture of raw materials.

The rock is transported from the quarry to the mill in cars, *C*, drawn by locomotives and by cable hoists or other mechanical means.

CRUSHING, DRYING, AND BLENDING

Crushing is done in two stages. At the crusher


SOME PLANTS USE OIL OR GAS AS KILN FUEL INSTEAD OF COAL
M
SKILLED OPERATORS WATCH THE BURNING
P
BLOWER
O
COAL GRINDING MILLS
N
COAL DRYER
COAL SAMPLE TAKEN HERE
RAILROAD CAR COAL
KILNS
CLINKERING ZONE TEMPERATURE 2500°-3000° F
Q
CLINKER COOLERS
ROLL CRUSHER


INSTEAD OF DRYING THE MATERIALS, IN WET PROCESS PLANTS WATER IS ADDED. OTHERWISE, OPERATIONS ARE ESSENTIALLY THE SAME AS IN DRY PROCESS PLANTS.
SAMPLE TAKEN FROM EACH BIN
STACK
H
I
J
K
L
KILN FEED
DRYERS
BLENDING BINS
BALL MILLS
TUBE MILLS
HOURLY SAMPLE TAKEN HERE
RAW MIX STORAGE
HOURLY SAMPLE TAKEN HERE
RAW GRINDING

house, cars are dumped into the hopper of the primary crusher *D*, generally of the gyratory type acting upon the principle of a huge nut cracker. Its product, consisting of 6-in. fragments or smaller, passes next to the secondary crusher, a common type being the hammer mill shown at *E*.

From this, the rock is elevated to the rock storage *F* and dumped into a number of bins, or a large bin, so arranged that the material can be withdrawn from any part of it. Hourly samples are taken, and the analyses of the rock govern the withdrawal for mixtures with the clay. The clay, passed through some type of disintegrator, is stored in a part of the raw storage *G*, which may be used for shale or slag storage if either of these materials is used in place of the clay.

If the dry process is used, these materials are passed through dryers to remove the moisture, a common type being the rotary dryer shown at *H*, which generally consists of a cylinder equipped with bars or lifters and supported on its side in a slightly inclined position so that, as it revolves, crushed rock works toward the discharge end. Hot gases from the firing end pass through the cylinder to the discharge flue, drying the crushed raw material. (If the wet process is used, water is added during grinding.)

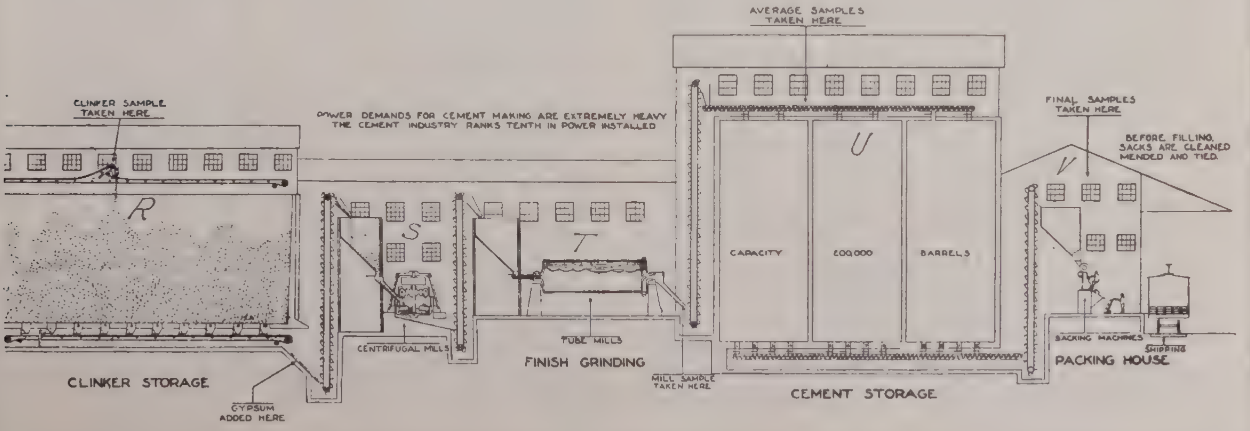
From the dryers, the rock is elevated and discharged to blending bins *I*, the contents of which are sampled and the samples recorded, so that the approximate mixture of limestone and clay materials can be made. The fine grinding of the raw material is generally done in two stages; the first stage being in the ball mill *J*, and the second stage in the tube mill *K*. Both grinding operations may be combined in one mill, in which case a different type of equipment is used.

The ball mill consists of a short cylinder, loaded with steel balls through which the material to be pulverized is passed. As the mill revolves, the balls rub together, reducing the rock particles. A tube mill is a longer cylinder, carrying 50 tons, or even more, of steel balls, flint pebbles, or other grinding media.

BURNING

In the raw mix storage, the finely pulverized raw material is held in bins from which the proper combination is drawn for elevation to the kiln feed. In a wet process plant, the bins are replaced by slurry storage tanks and correction tanks from which slurry is fed to the kiln. From the feed end of the kiln on, the processes are identical. The slurry is first dried out as it enters the kiln before the clinkering process takes place. Up to the feeding of the raw material to the kiln, the important factor is in obtaining an intimate mix of properly proportioned raw materials. In the kiln, the materials are burned to a clinker, as the result of the intense heat supplied by pulverized coal, gas, or fuel oil.

Rotary kilns, a typical installation of which is shown at *M*, are generally about 10 ft. in diameter or larger, and range in length from less than 100 ft. to more than 200 ft. The speed at which they rotate is varied according to the judgment of the burner in charge. These cylinders are lined with fire brick throughout their length. Over four and one-half million fire


AVERAGE SAMPLES TAKEN HERE
CLINKER SAMPLE TAKEN HERE
POWER DEMANDS FOR CEMENT MAKING ARE EXTREMELY HEAVY THE CEMENT INDUSTRY RANKS TENTH IN POWER INSTALLED
FINAL SAMPLES TAKEN HERE
BEFORE FILLING, SACKS ARE CLEANED MENDED AND TIED.
R
S
T
U
V
CAPACITY
600,000
BARRELS
CENTRIFUGAL MILLS
TUBE MILLS
FINISH GRINDING
SACKING MACHINES
SHIPPING
PACKING HOUSE
CLINKER STORAGE
GYPSUM ADDED HERE
MILL SAMPLE TAKEN HERE
CEMENT STORAGE

brick are used annually in kiln linings. The kilns are slightly inclined toward the discharge end, and as they rotate, gravity causes the material to pass toward the lower end, meeting the hot gases from the burning fuel. As the raw material first enters the kiln at the feed end, any remaining moisture is driven out. As the dried material works toward the lower or discharge end of the kiln, it becomes hotter, until it reaches the burning zone where a temperature is maintained from 2500° to 3000° F., which brings about the chemical combination between the lime and clay matter. Important changes take place during the burning. Carbon dioxide is almost entirely expelled, the water originally present, either free water or combined, is driven off. Carbon and organic matter are burned away and the iron oxidized. Sulfur is almost entirely expelled, what remains being present in the form of calcium sulfate. Alkali, potash, and soda are partly expelled in the kiln.

While the raw materials are being prepared for the kiln, coal, if such is used for firing, is put through a process in preparation for kiln firing. When first received at the plant, the coal is put through a crusher or disintegrator, when necessary, to break up large lumps, and it is then placed in a dryer, the usual form of which consists of a double cylinder with a passage for hot gases through the center, and the coal working its way to the discharge end through the annular space between the two cylinders. When properly dried, the coal is elevated to the feed hopper of the coal pulverizer, and after being pulverized, is again stored and used for firing the kiln and also some types of driers. In addition to the 9,000,000 tons of coal burned annually in the American cement plants, more than 3,700,000 bbls. of fuel oil, and 3,400,000,000 cu. ft. of natural gas are used. This is equal to 30,000 tons of coal or equivalent fuel every 24 hours.

The coal dryer is indicated at *N* in the sketch, the coal mills for pulverizing the coal are at *O*, and the pulverized coal is blown into the kiln by the blower *P*. Skilled operators watch the burning in the kiln, regulating the speed of the kiln, the kiln feed, the coal injected into the kiln for firing, and the amount of air allowed to enter the firing end. When pulverized coal is used for firing, the finely pulverized fuel burns as it is injected into the kiln under air pressure, forming a long jet similar to a large gas jet, extending several feet into the kiln.

As the clinker works its way toward the kiln's discharge end, it rides up on the inside lining of fire brick as the kiln revolves, falling back again through the hot gases, so that by the time it reaches the discharge end, it has been burned to a greenish black clinker, which falls out of the discharge opening at a temperature of about 2100° F.

Cooling, Storing, and Grinding Clinker

Before the clinker can be ground to finished cement, it has to be cooled, and this process may be carried out in different ways. A common installation is a cooler, operating somewhat similar to a kiln without any fire. The cooler is shorter than the kiln, and may be of the pressure type with cold air forced through in contact with the hot clinker, or it may be operated only with natural draft.

If no cooler is provided, clinker can be discharged into a pit, from which it is transported by some sort of drag conveyor and deposited into clinker storage until it is properly cooled for grinding. From the clinker cooler *Q*, the clinker is conveyed and elevated for discharge into the clinker storage *R*. If desired, the clinker can be taken immediately to the clinker grinding mill, instead of being sent to storage.

Samples of the clinker are taken as it is discharged into a clinker storage and the composition again checked.

On the way from the clinker storage to the grinding department, gypsum is added in an amount not to exceed 3% for the purpose of regulating the setting properties of the finished cement.

Like the fine grinding of the raw material, the grinding of the clinker is generally carried out in two stages. Typical installations used for breaking up the clinker and then for grinding it to the required fineness are shown at *S* and *T* in the diagram. The tube mill *T* is similar to that used for fine grinding of the raw material, and the process is practically the same, except that the fine grinding of the cement is always done dry, whether the plant uses the wet or the dry process. As in the raw grinding department, the finish grinding of the clinker may be done in one operation, where suitable equipment is installed.

Standard Specifications

Fine grinding is essential for good cement, and to this end specifications have been adopted governing the size of the finished product. Sieves for testing the fineness of cement are calibrated by the United States Bureau of Standards. The specifications call for a fineness which will allow at least 78% to pass through a sieve having 40,000 openings to the square inch.

The finished cement from the grinding mills is conveyed and elevated to the cement stock house or storage bins, where it is stored in bulk until such time as it is packed for shipment. A typical cement storage layout is shown at *U* in the diagram. Reinforced concrete silos are in common use. The cement is deposited by conveyors over the top of the various bins, and is withdrawn through openings in the bottom of the bins and conveyed and elevated to the packers.

Packing

In the packing room, the final samples are taken. Automatic packing machines fill the cement sacks, which are then conveyed or moved on hand trucks to the cars on an adjacent siding ready for shipment. Cloth bags which have been previously tied, or paper sacks which have been sealed, are filled through a valve-like opening in the corner of each bag. Previous to filling, new cement sacks are tied, and returned cement bags are cleaned, mended, and tied. In filling these sacks, it is necessary only to hang each sack on the bagging machine with the spigot on the machine inserted into the valve-like opening in the bottom corner. When the bag is filled to the proper weight, the flow of cement through the spigot is automatically shut off, and the bag drops off the machine onto a conveyor or hand truck.

Ninety per cent of the total production of cement is shipped in returnable cloth sacks containing 94 lb. of cement each. More than 200,000,000 cloth sacks are kept on hand at all times by the industry. To replace the entire supply at one time would require more than 200,000 bales of cotton. In addition to the cloth sacks, 7,000,000 lb. of paper is used in making non-returnable paper cement sacks.

More than 50,000,000 cloth cement sacks are lost or destroyed annually, the replacement of which requires a strip of cotton cloth 30 in. wide and 28,000 miles long—more than enough to reach around the earth at the equator.

The valve bags are pre-tied with small wire ties. Although the length of wire twisted around the neck of each cloth bag is small, the total amount used for that purpose by the cement industry annually is in excess of 46,000 miles.

The pressure of the cement on the inside of the sack closes the valve, so that in subsequent handling, very little cement is lost through the opening, and very little cement dust escapes during the filling operations. It is an interesting fact to note that, contrary to the one-time common belief, workers exposed to cement or other calcareous dust are less liable to tuberculosis and other pulmonary diseases than the average of the population.

Cement is a product manufactured by a process which must be accurately governed and in a plant costing from $2,000,000 to $5,000,000 to build. The cost of fuel, labor, and supplies must be taken into consideration and the very large investment needed, as well as the availability of raw materials, in establishing a new cement plant. The location of the mill with respect to its market is very important, since the bulk and weight of the cement are large compared to the price received for the finished product.

Present standard specifications for portland cement are the product of the best manufacturing and engineering minds in the country. Before leaving the mill, all cement must pass rigid tests for soundness, setting time, tensile strength, fineness, and specific gravity.

Portland Cement in the United States

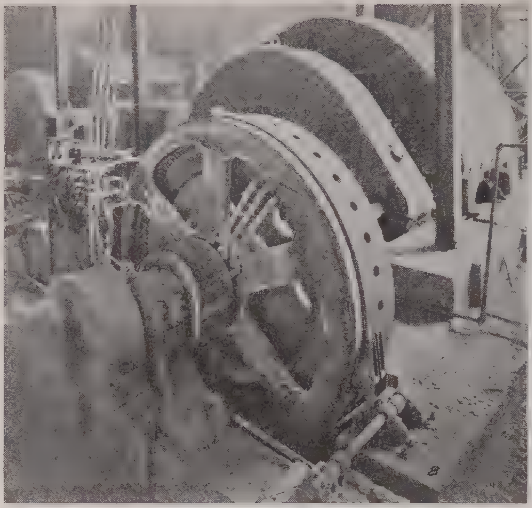
(Continued from page 132)

ascendancy over the natural cement industry. Mr. Humphrey, in speaking of the testing of cement for the city of Philadelphia, said that the city consumed each year about 120,000 bbls. of natural cement and about 50,000 bbls. of portland cement. "For store foundations, foundations for street pavements, etc., natural cement is used, while for the more important work—bridges, bulkhead walls, and concrete in large masses—portland cement is used. The natural cement to which I refer is not the natural cement referred to by Mr. Lesley, which is usually known as Roman or Rosendale cement, but it is an improved or a high grade natural cement, fully 50% stronger than what is usually known as natural cement; for the class of work referred to, the city finds this cement durable and economical. The average results of the tests made in the laboratory each year show marked improvement over the average results of tests of the previous year; while for the last two or three years, these tests show that the American cement (portland) is not only equal to the foreign cement in quality, but it is superior to it.

"This improvement in quality has been accompanied by a decrease in the price of cement. In 1892, high grade foreign portland cement brought from $2.45 to $2.85 per bbl., while natural cement brought from $1.20 to $1.40 per bbl. These foreign cements were gradually supplanted by a high grade American cement, until, in 1897, American portland cement brought on an average $1.90 per bbl. in bags, while natural cement brought on an average 95¢ per bbl. in bags; foreign cement of the same grade ranged in price from $2.15 to 2.85 per bbl. In 1892, the city required portland cement when tested to yield a tensile strength of 300 lb. per sq. in. at 7 days; while natural cement was required to stand 120 lb. after the same period of time. Specifications were increased each year, as was shown to be necessary by the average tests made during the year, until today the requirements are for neat portland cement 175 lb. in 24 hours; 500 lb. in 7 days; and 600 lb. in 28 days."

All this was in 1898.

In order to understand the developments in the manufacture of portland cement in this country and the vast improvements that have been made to put the industry where it is today, it is necessary for one to reverse the wheels of time and go back to a successful cement mill in the early 90's. In the quarry, many gangs of men are seen picking rock out by hand from the piles that have been thrown down from the various blasts. Carts in unending procession are marching over the quarry floor, and more men are, with hand power, throwing the selected rock upon them. No "safety first" committee is on the ground to watch the stripping or the possible falling of rock; all is man, horse, or mule power in the quarry work. In the mill, Gates crushers of a small size, shown in the pictures accompanying this article, struggle to crush the rock, large pieces of which in many cases have to be broken by hand power and hammers in the quarry before loading. From the Gates crusher, the material goes into a group of small crushers of the coffee-mill type, constantly granulating and constantly breaking down the raw mass. From the bins along the roof of the building, the material drops into a row of 30 or 40 stone Bur mills, where it is ground, as the Bible says, between the upper and the nether mill stones. The noise of the grinding is exaggerated by the constant clinck, clinck, clinck of the mill-stone cutters, who, with their sharp tools, are constantly sharpening the furrows in the stone mills, which, in turn, are constantly wearing out in the grinding work they are doing. Old vertical kilns of the intermittent type greet the eye, all loaded and unloaded by hand, though in later days, the short, rotary kilns were substituted for these old-fashioned instruments for calcination. Conveyors of small size and elevators of small size are constantly adding to the noise and the confusion, and the whole mill building, both raw and finished grinding, is filled with dust from mills, crushers, ele-



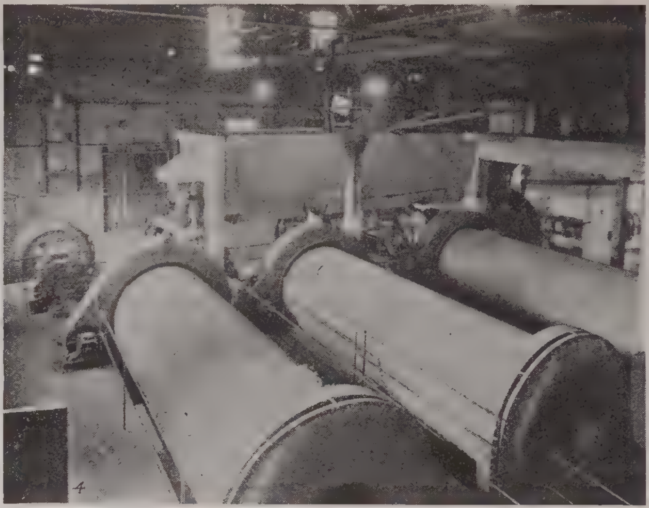


Fig. 9 (Left)—Modern Kominuter and Fig. 10 (Right)—Tube Mills in Cement Plant. These Machines Have Taken the Place of the Mill Stones First Used for Fine Grinding

vators, conveyors, and all the other machinery in operation. Man power is employed all over the mill, and when Griffin mills of the type shown were substituted for the mills stones, other gangs of men were constantly working repairing the new type of iron mill, where formerly they were working to keep the mill stones in order.

Summing up, therefore, what has been done in the improvement of machinery, the observer should take a look at some of the mills of the present time. The reader will get an idea of modern cement mill practice and the vast improvements that have been made to put the industry where it now is by referring to the article in the current issue of Concrete under the title "How Portland Cement Is Made."

It should be noted that marked progress has been made in the introduction of revolving kilns of large size, in more improved forms of grinding apparatus, kominuters, tube mills, Fuller mills, and Griffin mills, which have superseded the old types of Bur stone, with their accompanying coffee-mill crushers. The cleanliness of the mills is an object of the greatest interest to the observer, especially to him who was familiar with the industry in its early days. The strength and fireproof character of the buildings, the greatly improved and developed apparatus for handling both raw materials and finished products, the minimized manual labor, all of these are noted as bringing about a marked reduction in the price of portland cement and a constant increase in its use all over the country.

The substitution of improved kilns, methods, power plants, modern mill buildings, and modern engineering construction has involved greater cost and the larger capital outlay in the cement works of the present period. The plants of today are on a large scale, and are therefore under better administration and technical guidance, so that the quality and uniformity of the product are maintained as it was impossible to maintain them in the early days. Improvements in methods of testing and in the general accuracy of the results obtained have made the way clear for the standardization of portland cement under a single specification, so that manufacturers were able to concentrate their efforts to meet one single line of requirements rather than the many hundreds of specifications at one time brought before them.

The American manufacturers of portland cement use an exact mechanical and chemical process, involving, as one imaginative writer has put it, the tearing down and breaking up of a mountain and passing it through a silk handkerchief. Large quantities of raw materials must first be combined in the right chemical proportion and

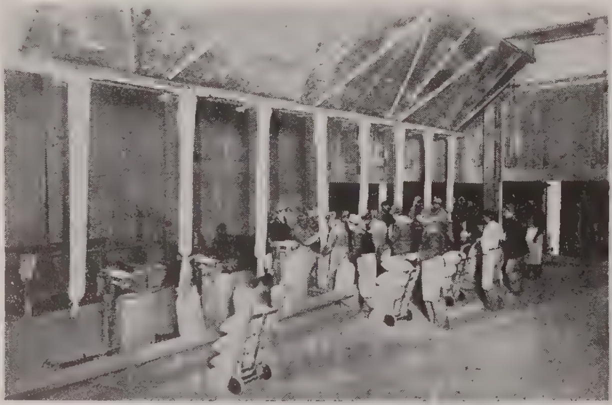


Fig. 11—Early Method of Filling and Weighing Sacks at Cement Plant

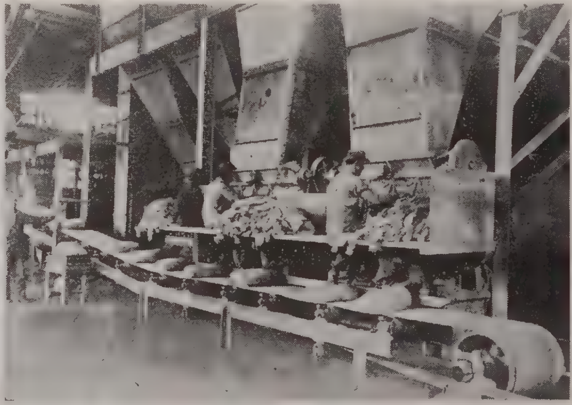


Fig. 12—Modern Packing Machines Automatically Filling Pre-Tied Cement Sacks

ground to extreme fineness. The proportioning is accomplished in machines under the constant control of chemists. Rock used for making portland cement is drilled by power drills and shattered by explosives and loaded by steam or electric shovels on cars and conveyed to crushers. Coal is handled and stored by cranes or other mechanical conveyors. Huge crushers built on the principle of a nut cracker and exerting enormous pressure, accomplish the reduction of the rock or other hard materials, while still other machines, by pounding and rubbing, pulverize the materials to their final condition of impalpable powder. In the paper before the American Concrete Institute (Vol. 20, 1924), Frederick W. Kelley, president of the Portland Cement Association, has very briefly summarized in five important factors the outstanding things in the development of the portland cement industry in United States, as follows:

"1. The systematic application of chemistry, making possible the use of many different kinds of raw materials, all having the necessary chemical composition.

"2. The development of efficient grinding machinery to reduce hard raw materials to proper condition for the raw mix.

"3. The development of the rotary kiln producing a uniform, well-burned clinker, with relatively cheap fuel and eliminating hand labor.

"4. The development of standard specifications, establishing minimum requirements for the product; permitting its manufacture from widely different materials, in places reasonably near to centers of consumption, and insuring a reliable cement, at all places, at reasonable cost.

"5. The systematic study of the best uses of concrete, and best methods for making it, thus insuring, as far as possible, the most economical and satisfactory results to users."

A final summary shows a few outstanding high lights.

The original natural cement industry grew in connection with the building of canals, which were the first means of heavy transportation in this country, succeeded shortly by railroads. This earliest public works development led to the establishment of plants to make mortar available for water use. When the railroads followed, the modern portland cement mills were distributed throughout the country regardless of waterways, but where the conjunction of available raw materials and fuel, possibilities for wide geographical distribution and good labor existed.

As cement itself was the outgrowth of engineering necessity, so the pioneers in cement production had their efforts furthered and upheld by the producers of mechanical equipment. Step by step, as the necessity for greater production, more rapid production, more economical production has arisen, there has come forward the mechanical means of accomplishing it. From the intermittent vertical kiln which gave about 200 bbls. of clinker every ten days to the first vertical continuous kilns of Germany with their limited output (owing to the lack of automatic feed and discharge) to the 60 ft. and 66 ft. rotary kilns then just coming in, are steps that indicate the steady progress in the field, and now we have come to those stages of the industry where the 150 to 200 ft. kiln becomes almost a modern production necessity.

The little Gates crusher which is shown in one of the accompanying illustrations was a great machine when it was set up. To compare this, or any one of a number of other great mechanical features of the early cement industry with modern usage in these particulars, is in itself to create a picture of the advancement of the industry.

The first Griffin mill ever used in the cement industry was at the Egypt mills of the old American Cement Co., and was adopted there after we had seen it in use grinding phosphate at a fertilizer plant near Boston. It took the place of the old mill stones, shown in another of the accompanying pictures, which were used to grind both cement and raw rock, by rubbing between the upper and the nether stones. This Bur mill required that the resultant product again be bolted in revolving reels. Compare such grinding apparatus with the enormous mills and kominuters now used in the cement plant.

There were further developments in the quarries, for in the early days the raw materials were almost all handled by man power and with carts.

Substitution of bags for barrels was an interesting mark of development. The barrel was essentially a package available for water shipment, as all the early mills were on waterways and were developed in connection with waterways, the barrel package was the natural outcome of the situation. For nearly a generation after the development of the railroads, and when the barrel had become a tremendous charge as a package, practice still clung to the use of the old water package at considerable useless cost because when once used it could not be returned and re-used. Substitution of the duck bag, a returnable rail package, for the barrel, a water package, was the work of the writer in persuading the architect of the United States Treasury Department to make the change on the first building for the Bureau of Engraving and Printing in Washington, in the early 80's and the bag has survived to the exclusion of the barrel.

Selling and promoting was a very difficult side of the industry, because it involved the introduction and use of a new material for building bridges, dams, and other structures. The foreign portland cement had been used for nearly fifty years and had justified itself. The American manufacturer had all this work to do over in the United States in introducing American portland cement. It was not like the sale of a new brand of beer, soda water or tooth paste. It was the sale of a permanent, durable material of construction upon whose permanence and endurance engineers and architects had to risk their reputations. On this side much is to be said of the work of the early pioneers in establishing the value of the American product in comparison with the European product which had been imported, and finally in reaching a stage where the American product was acknowledged the superior of the imported article. The thanks of the industry are due to the courageous and progressive engineers who gave American portland cement their confidence and support in its childhood days.

The Cement Industry in Canada

Limestones and dolomites containing sufficient clay matter to have hydraulic properties when burned occur in many parts of Canada. They have been utilized for many years for making hydraulic lime and hydraulic cement.

Hydraulic cement was made at Hull, Quebec, by Ruggles Wright, between 1830 and 1840. It was made at about the same time near the mouth of the Megdalen River, in the Gaspe Peninsula, Quebec, and at Kingston and Thorold in Ontario.

C. B. Wright & Sons, successors to Ruggles Wright, manufactured portland cement at Hull as early as 1889. The Rathbun Co. at Napanee Mills, Ontario, began the manufacture of portland cement in 1891.

The North American Chemical, Mining & Manufacturing Co., Ltd., was incorporated in 1888 for the purpose of manufacturing portland cement at Shallow Lake, Ontario. Up to this time, less than 800,000 bbls. of portland cement had been made on the American continent. One of the directors of this company, R. P. Butchart, is now president of the British Columbia Portland Cement Co., Ltd., Victoria, B. C. Learning that the rotary kiln was being introduced into cement manufacture in England, William Robinson, another director, visited England and purchased a rotary kiln, which arrived at Shallow Lake late in 1888 or early in 1889. It was 5 ft. in diameter and 25 ft. long, and was the first rotary kiln used in the manufacture of portland cement on the American continent. This plant was unsuccessful financially, and was superseded by the Owen Sound Portland Cement Co., Ltd., in 1892. This company installed at Shallow Lake in 1903 the first 100-ft. rotary kiln to be used on this side of the water.

As early as 1886, Thomas M. Morgan, at Montreal, Quebec, was convinced of the possibilities in cement manufacture. In 1888 a kiln and grinding machinery were erected, and several thousand barrels of Whites (English) cement, which had hardened in a warehouse fire, were reground and sold as portland cement. In 1889 he erected a mill at Longue Pointe, adjoining Montreal, which he operated until 1907, when he sold to the Vulcan Portland Cement Co., Ltd.

Following this early development of plants using crushed rock, there came from 1898 to 1905 some wild promotion of marl plants in Ontario. Eleven mills were erected during this period, but only three, The Hanover Portland Cement Co., Ltd., The Lakefield Portland Cement Co., Ltd., and The Ontario Portland Cement Co., Ltd., escaped a more or less disastrous end.

In 1889, the consumption in Canada was 122,273 bbls., all of which was imported. In 1890, 14,695 bbls. of Canadian made portland cement was sold, out of a total of 207,017 bbls. used. By 1900, 663,942 bbls. were consumed, of which 292,124 were made in Canada. In 1910, 5,103,285 bbls. were sold, of which 4,753,975 were made at home. The high point up to the present in the industry was reached in 1913, when the consumption was 8,913,014 bbls. During the war, the total dropped back until, in 1918, only 3,591,481 bbls. were used. There has been an irregular recovery since that date, the approximate figure for 1923 being 7,087,337 bbls., of which only two-tenths of 1% were imported.

From 1914 until 1923, the total consumption in Canada did not equal 50% of the reported capacity, and in 1923 it was only 55%. As the present export business represents less than 4% of the producing capacity, it is very evident that there will be no shortage of cement in Canada for many years to come, even if there is no increase in the producing capacity.

For much of the material in this article we are indebted to the volume on *The Cement Industry in Canada*, recently published by A. C. Tagge.

Graded Aggregate

Outlook

The Association of Building Trades Employers says that the passing of Labor Day marks the beginning of a new construction period, and that it is advisable to look into the future of the industry for the remaining four months of the year. "Conditions are more stable now than they have been any time this year. No marked wage fluctuations, either upward or downward, are in sight. The material market is operating on an even keel, and there is every reason to believe that there will not be much deviation from present prices during the balance of the year. Many investors have been waiting for assurance that building costs have been stabilized, and undoubtedly the next few weeks will bring out a large number of projects which were held up during the early part of the season. Conditions in other lines are rapidly improving."

Highway Research

Responding actively to the slogan "The practical application of highway research," sounded by Director Charles M. Upham, of the Advisory Board on Highway Research of the National Research Council, forty State Highway Commissions have already named representatives on this Board. Through the State representation, the Highway Commissions and the Advisory Board will have a medium whereby research problems may be thoroughly studied. The problems will be brought to the attention of the various States and others engaged in highway research, and the solutions will be made known to the State Highway Commissions through their representatives, or contact men. Announcement is made that the annual meeting of the Advisory Board will be held at the new National Research Council building, Washington, D. C., December 4 and 5, when the various committees will report and a program will be presented. It is expected that there will be present at this meeting a representative from each State Highway Commission, as well as representatives of the member organizations of the Board and others interested in its work.

The details of plan and procedure to be followed in the investigation of the economic value of reinforcement in concrete roads, are now completed, and field examinations are about to commence. Director Charles M. Upham reports that the various State Highway Commissions will actively cooperate with the board in conducting this investigation. Except in cases of actual failure, inspections will concern principally pavements having had at least five years of service, a great number of which are located in New Jersey; Ohio; New York; Pennsylvania; Delaware; Wayne County, Michigan; Milwaukee County, Wisconsin; Iowa; Illinois; and California.

In this intensive study, an effort will be made to determine, from a survey of existing roads, the influence of steel reinforcements on the resistance of the slab to traffic, subgrade, and climatic conditions; the conditions under which steel reinforcement is especially beneficial to concrete slabs; the effect of slab design on the efficiency of reinforcement; and finally, the relative cost of plain and of reinforced concrete roads, considering the initial investment, and the annual maintenance and renewal charges.

The procedure will consist of a personal examination of a sufficient number of existing road surfaces to cover different slabs, traffic, and climatic conditions. It is proposed to supplement the examination by photographs, sketches, soil determinations, and other available data.

Cinder Block Patent Suit

Genesee Brick & Supply Corporation, Rochester licensee of the Cinder Products Corporation (Bo patent) has filed its answer in the infringement suit commenced against it by Crozier-Straub Inc. (See CONCRETE, Aug. 1924, p. 75.) In addition to defending against the charge of infringement, a direct attack is made on the Straub patent.

American Concrete Institute's Annual Book—835 pages

A range and extent of subject matter to appeal to almost everyone with a practical or a theoretical interest in concrete is to be found in the 20th annual volume of the *Proceedings* of the American Concrete Institute (1807 East Grand Boulevard, Detroit), recently issued. It is a book of 835 pages. Aside from purely organization matters —officers, by-laws, membership, committees, etc., it presents the following papers and reports:

"Twenty Years of Concrete," by Richard L. Humphrey; "Cement Is the Magic of Concrete," by F. W. Kelley; "Concrete Roads," by A. N. Johnson; "Mass Concrete," by A. P. Davis; "The Mechanical Equipment for Handling Concrete," by A. W. Ransome; "Reinforced-Concrete Buildings," by Albert Kahn; "Concrete Bridges," by A. E. Lindau; "Concrete for Foundations and Water-Front Work," by M. M. Upson; "Concrete Products," by R. F. Havlik; "Architectural Concrete," by John J. Earley; "Engineering Research," by A. N. Talbot; "Making Good Concrete," by Duff A. Abrams; "The Promise of Future Developments," by Richard L. Humphrey; "How Structures Withstood the Japanese Earthquake and Fire," by H. M. Hadley; "The Earthquake in Japan," by Joseph S. Ruble; "Building Codes and Their Relation to the Concrete Products Industry" by William F. Lockhardt; "The Relation Between Wall Thickness and Diameter of Concrete Culvert Pipe for Highway Use," by G. W. Hutchinson; "A Demonstration in Making Trim Stone and Ornamental Concrete," by R. F. Havlik; "Old and New Methods of Constructing Concrete Bridges," by J. B. Hunley; "Weighing Concrete Aggregates on Highway Pavements," by R. W. Crum; "Economic Value of Admixtures," by J. C. Pearson and Frank A. Hitchcock; "What We May Expect to Do with Aluminate Cement," by Henry S. Spackman; "Field Tests of Concrete," by John G. Ahlers and Stanton Walker; "Control of Concrete for the University of Illinois Stadium," by W. A. Slater and R. L. Brown; "Field Tests of Concrete Used on Construction Work," by W. A. Slater and Stanton Walker; "Discussion of the Results of Tests of Job Concrete," by Walter P. Bloecher; "Tests of Impure Water for Mixing Concrete," by Duff A. Abrams; "Building Fireproof Homes," by Paul Hueber; "A Study of Bending Moments in Columns," by F. E. Richart; and reports of the following committees:

Question Box for Construction Superintendents and Products Plant Problems (report of two special "round table sessions").

Field Methods; Destructive Agents and Protective Treatments; Nomenclature; Fire Resistance of Concrete Building Units; Recommended Practice for the Design and Construction of Concrete Dwelling Houses (Report of Committee S-5); Expansion Joints in Concrete Construction; Concrete Products Plant Operation; Waterproofing; Contractors' Plant; Concrete Staves.

"Tentative Standard Specifications and Building Regulations for Concrete Staves"; Standard Building Units; "Tentative Standard Specifications for Concrete Building Block and Concrete Building Tile"; Tentative Standard Specifications for Concrete Brick"; "Tentative Standard Specifications for Plain Concrete Sewer Pipe"; "Tentative Standard Specifications for Concrete Drain Tile"; "Tentative Standard Specifications for Reinforced-Concrete Sewer Pipe"; "Standard Specifications for Portland Cement Concrete Pavements"; "Tentative Standard Specifications for Portland Cement Concrete Pavements"—One-Course Portland Cement Concrete Pavement for Highways; Two-Course Portland Cement Concrete for Highways; One-Course Portland Cement Concrete for Street Pavements; Two-Course Portland Cement Concrete Street Pavements; "Tentative Standard Sepcifications for Portland Cement Concrete Sidewalks"; "Standard Specifications for Concrete Floors"; "Standard Specifications for Monolithic Concrete Sewers and Recommended Rules for Concrete Sewer Design".

Plasterers and Terrazzo Workers

Several large building operations were tied up in Pittsburgh, due to the refusal of plasterers to work on jobs where terrazzo workers affiliated with the bricklayers were employed. The trouble started when the terrazzo workers, who were formerly affiliated with the cement finishers, organized a local of their own and became a part of the bricklayers' organization.

Standards for Steel Reinforcing Bar Sizes

Steel manufacturers, big distributing interests, representatives of the Associated General Contractors of America, and other consumer representatives, meeting in the Division of Simplified Practice, Department of Commerce, early in September, adopted as standards for steel reinforcing bars eleven sizes, based on the area of the bars. This action, effective on January 1 for producers and on March 1 next for distributors who have stocks or current orders to be cleared before the completion of the action, will replace some forty or more sizes in use.

A. E. Lindau, President of the American Concrete Institute, represented Institute, Detroit, and the American System of Reinforcing, Chicago, and outlined the pre-war experience as to varieties demanded. He showed how in a single plan, 18 to 20 sizes of reinforcing bars were frequently called for, some with as little as $\frac{1}{16}$ in. variation. The demand was curbed during the war, but had since backslid to nearly as great a variety as before. He declared that certain state highway departments had standard plans which included other than the suggested standard sizes, and that a certain amount of hesitancy might be found before changes to the standards would be made. W. A. E. Doying, of the Panama Canal, O. L. Grover, of the Bureau of Public Roads, Department of Agriculture, and A. W. Slater, of the Bureau of Standards, spoke in favor of the proposed standards.

E. F. Kelley, representing the American Association of State Highway Officials, and W. O. Irwin, of Youngstown, O., representing Truscon Steel Co., discussed highway construction. Mr. Irwin disclosed that from the distributors' standpoint, the present variety is tying up huge sums in stocks, and that the consumer has to pay the interest on the investment. Pacific Coast points, he said, call for a greater variety than the central and eastern parts of the country.

George E. Routh, Jr., of the Kalman Steel Co., Chicago, recommended that the area of bars be considered for standardization rather than the shapes, a position which was endorsed by Richard L. Humphrey, of Philadelphia, who represented both the Joint Committee on Concrete and Reinforced Concrete and the American Society for Testing Materials. Other speakers included Commander Ralph Whitman, of the Navy Department; C. A. Bissell, of the Reclamation Service, Department of the Interior; J. H. Gray, of the American Telegraph & Telephone Co.; E. P. Goucher, of the American Electric Railway Association; M. W. Lewis, of the office of the Chief of Engineers, War Department; D. H. Sawyer, of the Associated General Contractors of America; Dr. John M. Gries, Chief of the Division of Building and Housing, Department of Commerce.

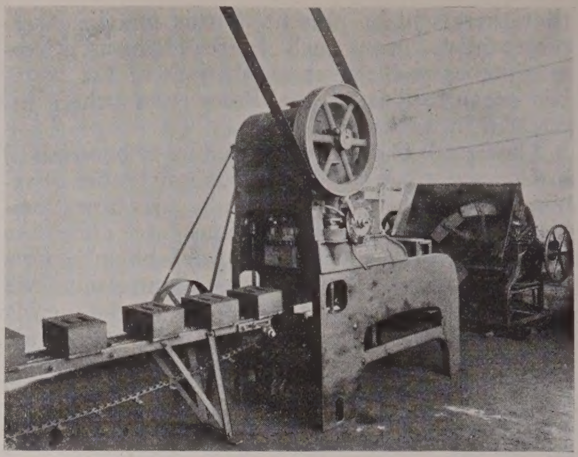
The areas in inches of the standards adopted were as follows: .049, .110, .196, .250, .307, .442, .602, .785, 1.000, 1.266, 1.563.

New Automatic Molding Machine

The term, automatic, has been rather loosely applied in the past to equipment used in concrete products plants, just as it has had generous application to machinery in all fields.

Therefore the announcement of a new automatic machine for the quantity production of concrete building units, coming from the Blystone Manufacturing Co., Cambridge Springs, Pa., is particularly interesting when the actual operation of the machine is observed.

The Blystone Automatic Molding Machine actually functions without attention, save in emergencies, if it is kept supplied with pallets and mixed concrete. As installed, a Blystone mixer dumps its charge into the boot of a conveyor. From that operation to the point where the finished product is taken off a moving conveyor human labor is not involved.


The New Blystone Machine

A spiral screw enclosed in the conveyor elevates the mixed concrete to the top of the machine. Cast-iron pallets feed automatically, one at a time, into the machine, which automatically feeds into the mold box a measured batch of material in excess of the amount needed to cast a unit. The machine automatically subjects the charge to pressure, removes the surplus material (which becomes immediately available as a part of the next charge), strips the unit and discharges it onto a moving conveyor which carries it away, at the rate of five standard block or tile per minute.

With the mixer kept running, the only labor required in the molding process is to keep the pallet rack charged and to remove the product from the conveyor. The machine automatically conducts all other operations without any levers being pulled or any buttons pressed. If a pallet should get in cornerwise or some hard foreign material get into the mold box, the machine automatically stops and rings a bell asking for help. Structurally, the machine is heavy—in appearance it compares favorably with machine tool equipment seen in the ordinary modern machine shop.

The application of hydraulic pressure in this equipment is new. The pressure is obtained by the use of a four-cylinder pump, oil being the liquid used. All parts of the pump are immersed in oil, and a high-pressure lubricating system forces oil into all bearings. Every operation is controlled and the pressure distributed by the use of a many-way valve. A safety valve is provided which automatically stops the machine in emergencies as outlined above. An observer may tell progress of the molding operation by watching a dial on the side of the machine.

Seven horse power is required to operate the equipment, which has a rated capacity of 300 block or tile or 1500 to 1800 brick per hour. The product of the machine has been subjected to rigid tests, and has developed strengths well above the most rigid building requirements.

X-Ray for Locating Reinforcement

The Bureau of Standards says that an interesting possible commercial application of X-ray was suggested in a conference with a consulting engineer, namely, that of locating steel reinforcement rods in concrete girders in buildings already constructed, and thus avoid mutilating the structure. The practical difficulty is that very powerful X-ray equipment would be required to penetrate large girders.